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Emerging trends in European food, diets and food industry

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ABSTRACT

Understanding how an adequate food security may be determined, how nutritional intakes evolve over time and are influenced by global dynamics are few of the questions scholars are trying to answer. In addition, a great interest is devoted to the changes in consumers' preferences and expectations as well as to the analysis of food innovations and their impact on the global market. We review the recent and emerging trends in food supply chains of selected sectors (fruits and vegetables, meat, and seafood), and deepen on emerging trends in the food industry. By presenting the evidence provided by the literature and emphasizing the unresolved research questions, we offer a critical view of future directions that should be followed by research agenda.

1. Introduction

During the last decades, the global dynamics in food production and consumption have evolved rapidly. The FAO estimated that the (per capita) calorie availability of 2196 kcal/day in 1961 raised to 2870 kcal/day in 2011 (FAO, 2015). On one hand, the increase in prices has led to an over-supply, on the other hand the unequal distribution of production and incomes has exacerbated the problems of access to food (Barrett, 2002; Caracciolo & Santeramo, 2013; Otsuka, 2013). As a result, the measurement and investigation of the access to food, a key dimension of food security, has become a priority in developed and developing countries (Barrett, 2010; Leroy, Ruel, Frongillo, Harris, & Ballard, 2015; Muchenje & Mukumbo, 2015; Santeramo, 2015a, 2015b). A further aspect of high relevance is the assurance of adequate nutritional quality and quantity, which also impact on food security status. Changes in income and prices have been proved to be potentially disruptive for the correct balancing of the diet (Santeramo & Shabnam, 2015; Zhou & Yu, 2015). Moreover, the recent economic crises, joined to the high price volatility, have had severe consequences on global trade, global production and thus, on global availability of food (Bellemare, 2015; Santeramo, Carlucci, De Devitiis, Nardone, & Viscecchia, 2017; Santeramo, Lamonaca, Contò, Stasi, & Nardone, 2017). It is not surprising that diets have become less and less balanced. The prevalence of diseases linked to the consumption of unbalanced diets increased.

Studies have shown the causality relationships between dietary patterns and lifestyle habits versus chronic illnesses (Jacques & Tucker, 2001; King, Mainous, Carnemolla, & Everett, 2009; WHO, 2003). As

such, the extreme importance of eradicating food insecurity, one of the Sustainable Development Goals in developing and developed economies, is pushing research to increase the effort to understand the trends in the global supply chains, the changes in consumers' expectations, the evolution of the food industry, and the potential impacts of innovations (Gereffi & Lee, 2012; Parfitt, Barthel, & Macnaughton, 2010). Based on these premises, it has been provided a wide, yet not exhaustive, review on the emerging trends in selected supply chains of the food industry. In particular, selected “case studies” are provided: trends in three different food supply chains, namely fruits and vegetables, meat and meat products, and seafood products; the emergence of innovations in the food industry and, in particular, the development of novel foods, the evolution of functional foods and the use of nanotechnology. Recent changes in consumers' choices have been emphasized and the up to date knowledge has been reviewed so to suggest future direction for research agenda. As for the trends in the global food industry, the increasing use of functional foods (Siro, Kápolna, Kápolna, & Lugasi, 2008), the development of novel foods industries (Dovey, Staples, Gibson, & Halford, 2008), and the emergence of nanotechnologies in the food sector (Coles & Frewer, 2013) are likely to represent new frontiers worth great attention.

The review is organized so to have, for each “case study”, a preliminary description of the recent market dynamics so to highlight trends in consumption and in production, a review of consensus reached by the literature, and a critical view of what is lacking and left for future advancements.

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2. Trends on supply chains, diets and the industry

2.1. Fruits and vegetables

The Fruits and vegetables (F & Vs) sector is growing rapidly worldwide (Pilone, Stasi, & Baseliace, 2017; Santeramo, 2015c; Santeramo & von Cramon-Taubadel, 2016; Seccia, Santeramo, & Nardone, 2015). The main reasons of the market growth are a growing consumers' interest in ready to eat food (Artés, Gomez, Aguayo, Escalona, & Artés-Hernandez, 2009), and a growing demand of food with higher safety standards (James, Ngarmasak, & Rolle, 2010). Worldwide, while the demand for ready to eat concerns more western countries, such as Europe and Northern American countries, safer food production has a global interest, including developing countries, due to the high potential of exporting “exotic food” to western countries (James et al., 2010). In addition, the positive effects of F & Vs consumption on human health tend to increase consumption of F & Vs. High consumption of F & Vs, in place of consumption of food with high intake of carbohydrates and fats (i.e. pasta, meat preparations, etc.), is likely to reduce overweight problems and cardio vascular diseases. The WHO recommended level of daily consumption of F & Vs is as high as 400 g per capita (WHO, 2008). In the European Union, six member states out of 28 met the WHO recommendation (Freshfel, 2014). However, the low efficacy in reaching WHO recommendations led governments to launch educational initiatives in order to raise public awareness on this issue, despite the impacts on the population are still questioned (Mazzocchi, Traill, & Shogren, 2009). In 2008, the EU Ministry of Agriculture approved the introduction of an EU School Fruit Scheme, to support the increase in consumption of fresh F & V in schools, which has been claimed to have a positive impact on intake of F & Vs (Wingensiefen, Maschkowski, Höllmer, Simons, & Hartmann, 2012). In other terms, the consumption of F & Vs is suggested in developed countries and scholars are interested in understanding (and quantifying) the impacts of F & Vs on human health.

Fresh-cut products, being ready and of easy consumption, represent an interesting innovation for the industry. In fact, during the last decade, the fresh-cut sector showed a large expansion. According to the International Fresh-Cut Produce Association definition, fresh-cut F & V are minimally processed products, washed, cut, mixed and packed. They have been introduced in EU in the 80s and are likely to represent one of the most importance innovation for the industry, capable of reshaping consumption patterns. Quality innovations are contributing positively to their diffusion (Artés et al., 2009).

The market for fresh-cut F & V in Europe, since its origin in the early 80's, has been characterized by a double digits growth, although it is gradually slowing down. However, despite the continuous growth of the fresh-cut F & V consumption, its market share is still represented by few percentage points. In 2010, fresh-cut fruit market share was about 1% of total volume of fruit sold in the Europe. For fresh-cut vegetables, the situation is slightly different: the market share has increased by 4% with respect to the total volume of vegetables (Rabobank, 2011). In addition, packaged salads appear to be the leader of fresh-cut products and represent about 50% of total fresh-cut market volume. The other 50% is shared by the fresh-cut fruit (10%) and the other categories as ready-to-cook, crudités and other with 40% (Rabobank, 2010).

Fresh-cut F & V quality improvements, from safety and packaging standpoints, are constantly evolving and it highlights the growing interest towards food safety characteristics and quality preservation techniques (Baseliace, Colantuoni, Lass, Nardone, & Stasi, 2017). As for consumption of F & Vs, Pollard, Kirk, and Cade (2002) showed that sensorial profile, social interactions, time constraints, costs, advertising and personal ideology affect F & V choices. Cassady, Jetter, and Culp (2007) investigated the negative relationships between income and convenience food purchase, and concluded on the existence of a budgetary barrier. Frewer et al. (2011) and Buckley, Cowan, and McCarthy (2007) pointed on the importance of other limiting factors for consumption such as limited spare time, social environment and eating out.

de Boer, McCarthy, Cowan, and Ryan (2004) compared convenience categories (take-away meals, ready meals, and pub-restaurant meals) and concluded that convenience food choice is positively related to the lifestyle (social events breakdown of mealtimes, eating alone, novelty) and time constraints, but negatively associated to cooking ability and importance of freshness into food choice.

However, ready to eat consumers preferences are not only related to convenience but also to the perception of food safety. In fact, Deliza, Rosenthal, and Silva (2003) showed that food choice is related to labeling information, nutritional facts readable on the pack as well as, safety descriptors. Cardello, Schutz, and Leshner (2007) discussed on innovative technologies, generally associated to potential health risk, and cold preservation, that tend to generate positive perception. Cardello et al. (2007) has also shown that “minimally processed” descriptors are negatively perceived, possibly due to their association to other food safety risks. As already mentioned, the packaging is also an important driver of consumers' choices. Peters-Texeira and Badrie (2005) found that packaging is second (for relevance) with respect to convenience, and it is more important than brand and visual impact in the consumers decision making process for ready-to-eat products.

The literature on fresh-cut F & V consumers' preferences share analogies with the literature on ready-to-eat products, but remarkably differences exist. Jaeger and Rose (2008), found that eating moments, especially driving and eating outdoors, are important factors in determining fresh-cut fruit consumption. Cassady et al. (2007) concluded on inverse relationships between fresh-cut fruit consumption and income levels. In addition, they highlighted the role of the packaging and of the country of origin and conclude on the importance of those attributes for consumption choices. Ragaert, Verbeke, Devlieghere, and Debevere (2004) have also concluded on the relevance of appearance and packaging. von Germeten and Hirsch (2015) highlighted that bag packaging, sliced product and portioned items impact on children's F & Vs liking: their conclusion reinforce the link between perception of food safety and consumption choices. Laureati, Bergamaschi, and Pagliarini (2014) and Mustonen, Rantanen, and Tuorila (2009) built on existing evidence and showed that safety perception is also connected to product familiarity. Last but not least, Koutsimanis, Getter, Behe, Harte, and Almenar (2012) concluded on the importance of the materials adopted for the packaging.

To sum up, the current literature has underlined the role of attributes associated to safety, and showed their importance in orienting consumers' choices. Packaging solutions are also important determinants of trends in consumption of F & Vs.

2.2. Meat and meat products

The consumption of meat and meat products is expected to be steadily decreasing in developed economies (Vranken, Avermaete, Petalios, & Mathijs, 2014), but to increase in developing economies: as a result the demand for meat is expected to increase (Fig. 1). In fact the tendency towards a lower consumption in developed economies is predicted to be largely balanced by a rapidly raising demand in economically emerging countries, due to the increase in population and incomes (Meade & Rosen, 2013). In affluent economies, changes in meat consumption habits are driven by the heterogeneity in the valuations of product characteristics by individuals (Gracia & de Magistris, 2013) and by the increasing relevance of health concerns, ethical and ecological issues (Vanhonacker, Pieniak, & Verbeke, 2013). Indeed, consumers declare to be interested in qualitative attributes such as food safety, country of origin, organic production and animal welfare. The origin of such interest is possibly due to the recent meat safety crises (Verbeke, Pérez-Cueto, de Barcellos, Krystallis, & Grunert, 2010), to the raising concerns on health issues (Pan et al., 2012), on sustainability (Aston, Smith, & Powles, 2012; Austgulen, 2014), to the consumer dissatisfaction towards traditional muscle-type meat (Hocquette et al., 2013; Verbeke et al., 2010), and towards traditional production

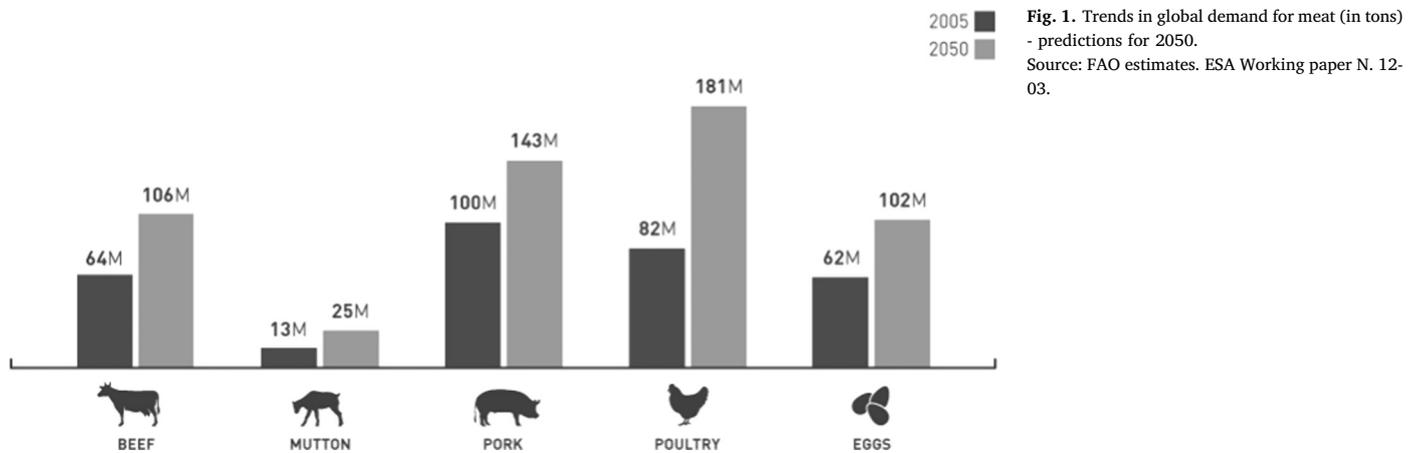


Fig. 1. Trends in global demand for meat (in tons) - predictions for 2050. Source: FAO estimates. ESA Working paper N. 12-03.

practices (Troy & Kerry, 2010). Although the negative image of the product and the general declaration of consumers to be concerned about animal welfare, their purchase behavior is different from their claim (Font-i-Furnols & Guerrero, 2014). A study realized in Europe showed that consumers give high importance to environmental and animal welfare issues but there is often a gap between attitudes and behavior (Verbeke et al., 2010). On the other hand, a more powerful reason for the change of habits in meat consumption is the concern about safety and health (Clonan, Wilson, Swift, Leibovici, & Holdsworth, 2015).

People's behavior could be different in relation to specific types of meat (Guenther, Jensen, Batres-Marquez, & Chen, 2005) or to innovative products with different healthy characteristics (Guàrdia, Guerrero, Gelabert, Gou, & Arnau, 2006), and labels may play a key role on purchasers' trust (Corcoran et al., 2001). Healthy versions of meat products are not always accepted; a majority of consumers prefer to reduce or eliminate the consumption of the meat (Guerrero et al., 2011). Changes in purchasing motivations have enhanced the importance of visual appearance attributes in supporting consumer evaluations (Grunert, 2006). Clear label information tends to positively influence consumers' purchasing intentions and their willingness to pay for desired attributes. The communication of the origin of meat is also able to influence health concerned consumers (Verbeke & Roosen, 2009). For instance, Font-i-Furnols et al. (2011) concluded on the relevance of the country of origin label and show that consumers tend to prefer beef and lamb of domestically produced. Consumers are also influenced by the Designation of Origin and Geographical Indication which tend to reinforce the trust and to modify the preferences towards products of specific origin and with proven high standards of production (Grunert, 2006).

Another attribute related to quality label, associated to a price premium that consumers are willing to pay, is the certification of organic production (Van Loo, Caputo, Nayga, Canavari, & Ricke, 2012). The purchase of organic meat is driven by the perception that organic meat is safer, healthier, ethic, more environmentally-friendly and is produced employing better animal welfare standards (Fernqvist & Ekelund, 2014).

Segments of consumers differ significantly by their attitudes towards farming animal welfare (Heise & Theuvsen, 2017) and their willingness to pay a price premium for products associated with high standards of animal welfare (Liljenstolpe, 2008). The willingness to pay more has been found higher for women and for consumers with higher level of education and income (Kehlbacher, Bennett, & Balcome, 2012). A relevant role in influencing the purchase behavior for food products labelled "animal-friendly" is played by the importance of informing consumers and by the level of trust that consumers tend to have after having been informed on food (Vanhonacker & Verbeke, 2014). The effect of information, linked to sensory aspects, is particularly relevant

in the case of meat products with healthy and nutrition properties, as well as for functional meat products (Olmedilla-Alonso, Jimenez-Colmenero, & Sanchez-Muniz, 2013). Sensorial attributes are likely to gain further importance in that taste is a major determinant of consumption choice in the food industry (Marino, Albenzio, Della Malva, Muscio, & Sevi, 2015; Miller, Carr, Ramsey, Crockett, & Hoover, 2001). In addition, changes in consumer acceptability for new preparations are likely to lead to the development of new products (Marino et al., 2017). Future opportunities for producers are based on the high segmentation of the market for meat products, and on the potential strategies of differentiation that may be implemented in order to meet the public interest towards sustainability issues, environmental efficiency, impact of carbon footprint, animal welfare and healthiness (Kristensen, Støier, Würtz, & Hinrichsen, 2014).

In a nutshell, consumption are evolving rapidly, the importance of sensorial attributes is likely to become very relevant in orienting consumers' choices in the near future. The meat industry should be prepared for these substantial changes and to face these global challenges.

2.3. Seafood products

Global fish consumption has grown steadily in the last five decades, from about 30 million tons in 1960 to over 130 million tons in 2012 (FAO, 2014). This impressive development of global fish consumption has been driven by a combination of population growth, rising incomes and changes in food habits, as well as strong expansion of fish production. However, the increasing fishing pressure has led to a severe depletion of natural fish resources since 1990s (FAO, 2014). Currently, the increasing global fish production is assured by aquaculture which provides about half of global fish production and is one of the fastest growing food sector in the world (Fig. 2). In the EU, aquaculture is an important activity for many coastal regions and provides about 20% of total fish production (European Commission, 2014). However, from 2000 to 2012, while the world aquaculture production has more than doubled, from 32.4 to 66.6 million tons, the EU aquaculture production has fallen from 1.4 to 1.3 million tons (FAO, 2014). This is remarkable, considering that the EU market of fish and seafood is mostly supplied (65%) by imports (European Commission, 2014).

The growing consumers' expectation for food quality is offering new business opportunities for EU aquaculture producers who are willing to differentiate their products and serve specific markets (European Commission, 2014). In line with this consumer-oriented approach, new labeling provisions are contained in the reform of the Common Market Organization (CMO) in fishery and aquaculture products (Reg. EU No 1379/2013). Fish products sold to consumers must bear mandatory information such as the commercial and scientific name of the species, whether the product was caught or farmed, whether the product is fresh or has been defrosted, and the date of minimum durability. In addition,

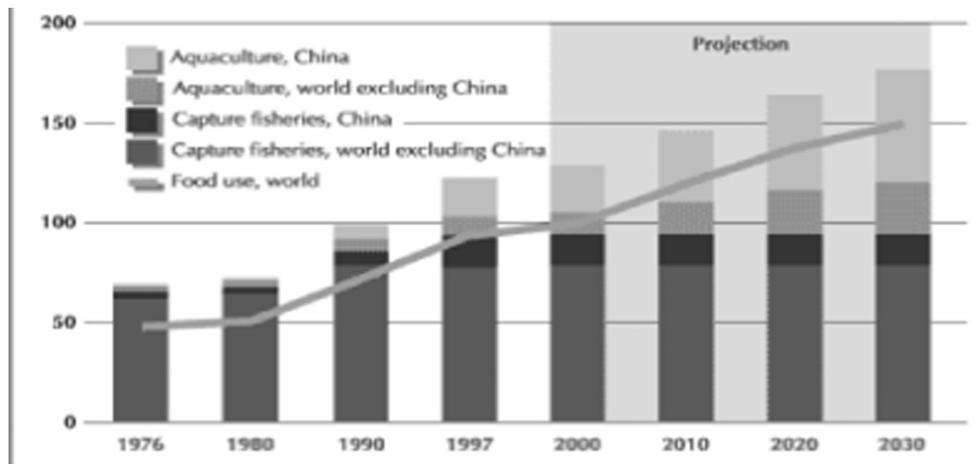


Fig. 2. Trends in global demand and production of seafood products (mln tons). Source: FAO estimates.

no farmed fish must display detailed information on the fishing area so that consumers have a better understanding of the product origin, while farmed fish must bear the indication of country of origin. Additional voluntary information can be provided only without reducing the space available for mandatory information on the label, and they must be also clear, unambiguous, and demonstrable.

The mandatory country-of-origin labeling for farmed fish is expected to increase EU aquaculture competitiveness, and is generally considered one of the most important fish attributes for consumers. They have a clear preference for domestic fish products, perceived as superior for quality, safety and freshness with respect to imported fish. However, the quality of fish products depends upon several attributes which affect consumers' choices and satisfaction. It is also important to distinguish objective and subjective quality of fish (Fernqvist & Ekelund, 2014). Objective quality refers to the physical product characteristics that should be desirable for consumers and it is typically evaluated by experts such as food technologists and dietitians. Subjective quality refers to how consumers perceive quality attributes. The relationships between the two dimensions of quality are of crucial importance because only when producers can translate consumers' wishes into physical product characteristics, and only when consumers have a real perception of their desired characteristics on the available products, quality will be an effective competitive tool for producers. Quality perception seems to play a key role in the market of fish and seafood products. Beyond from the personal factors including values, beliefs, attitudes, and demographics, the perception of quality also depends on how consumers infer quality from a variety of signals and other information sources (Fernqvist & Ekelund, 2014; Fonner & Sylvia, 2014). Specifically, the most important quality attributes of fish and seafood, such as freshness, naturalness, healthiness, nutritional value, geographical origin and production method are “credence” attributes and cannot be assessed by consumers even after consumption. Therefore, consumers need to use extrinsic cues such as price, labeling and other sources of information to infer on fish quality and form quality expectations.

Based on these premises, it may be argued that informative food quality and safety certification labels have a significant influence on consumer choices. Recently, third-party certifications and related labeling (e.g. organic labels, eco-labels, fair-trade labels) are emerging as effective instruments for ensuring food quality and safety in the global agrifood system. They are perceived as objective and independent (Albersmeier, Schulze, Jahn, & Spiller, 2009; Hammoudi, Hoffmann, & Surry, 2009). However, agrifood systems are increasingly pervaded by a plethora of certification schemes with heterogeneous importance.

Rortveit and Olsen (2009) found that consumers tend to perceive fish as a fairly inconvenient food in that it requires time-consuming

preparation efforts. In addition, Pieniak, Verbeke, Scholderer, Brunso, and Olsen (2007), Rortveit and Olsen (2007), Verbeke, Vermeir, and Brunso (2007), and Carlucci et al. (2015) showed that high levels of knowledge, experience and expertise are necessary for selecting and preparing fish, particularly fresh fish. On the other hand, increasing levels of processing influence consumers' perception of fish quality in a negative way such as loss of naturalness, healthiness and nutritional value (Arvanitoyannis & Bosnea, 2004; Carlucci et al., 2015; Debucquet, Cornet, Adam, & Cardinal, 2012). Verifying such hypothesis is an important empirical question. In particular, Santeramo, Carlucci, et al. (2017) and Santeramo, Lamonaca, et al. (2017) show that consumers' choices are proved to be strongly affected by their attitudes towards food safety and environmental issues: expertise in judging food safety influences both the location and the frequency of consumption. Carlucci, De Devitiis, Nardone, and Santeramo (2017) found that certification labels are more effective than new convenient preparation formats in differentiating high quality products in the aquaculture market. Investigating consumers' preferences towards labels, certifications and convenient preparation remains an important and promising research line that calls for further investigations.

3. Trends in the food industry

3.1. Functional foods

Consumer demand for health-enhancing food products, such as functional foods (Ffs) has grown rapidly. The term “functional food” is generally used to communicate either that the food may provide health benefits beyond those delivered by traditional nutrients, or that the food has potential in preventing disease or in promoting a better life quality (Griffiths, Abernethy, Schuber, & Williams, 2009). A recent report assesses the value of the global market for functional foods: it reports \$168 billion for 2013, and forecasts more than \$300 billion for 2020. This growing market perspective has driven several food companies to invest in the development of new functional products (Khan, Grigor, Win, & Boland, 2014). However, the development of new functional foods is a risky activity in that the majority of new functional foods marketed are withdrawn shortly after their launch (Mellentin, 2014). This high rate of failure is due to the fact that the product development is often driven by technical feasibility (Bleiel, 2010) and not by the potential acceptance among consumers (Van Kleef, van Trijp, & Luning, 2005). In light of these considerations, several consumer studies, conducted in Northern European countries, have given great emphasis to consumer awareness, preferences, attitudes, perception and purchase intentions towards Ffs of various categories such as dairy, meat, bakery, and beverages. Scientific evidence suggests that factors affecting the consumers' acceptance and preferences for

functional products may be grouped in consumers-related-characteristics and in product-related-characteristics. As far as the former, they can be classified into Personal Factors (PE), Psychological Factors (PS) and Cultural & Social Factors (CS) (Kaur & Singh, 2017). As for the PE, high income and high education is associated with positive consumer behavior (Hung, de Kok, & Verbeke, 2016; Hur & Jang, 2015; Jezewska-Zychowicz & Krolak, 2015; Schnettler et al., 2015). As for age and gender, three systematic reviews on functional foods, including studies covering different product categories (Kaur & Singh, 2017; Ozen, Bibiloni, Pons, & Tur, 2014) concluded on the difficulty to identify how the two characteristics influence the consumption of Ffs. Recently Bimbo et al. (2017), by focusing on functional dairy products, concluded that female and older consumers are more likely to be willing to try and to include Ffs in their diet. Finally, familiarity with, and health consciousness, increase the chances of consumption of functional foods (Hung et al., 2016). Consumers' psychological traits also contribute to shape acceptance and preferences for functional food products. In particular, attitude/motivation towards Ffs, health motivations, perceived benefit and risks are good predictors of the likelihood of purchasing functional foods (Cox, Evans, & Lease, 2007; Hung et al., 2016).

Moreover, the consumption of Ffs is positively influenced by socio-cultural factors. The likelihood of functional food acceptance increases with the presence of an ill family member, with doctors/dieticians being the source of information (Loizou, Michailidis, & Chatzitheodoridis, 2013) and with the presence of children at home (Bechtold & Abdulai, 2014). As for the product related characteristics, the functional ingredients and the base products have varying effects on Ffs consumption (Bitzios, Fraser, & Haddock-Fraser, 2011; Fiszman, Carrillo, & Varela, 2015; Kraus, 2015). Functional ingredients and base products are valued better than others; carrier product may receive greater importance than functional ingredients (Bitzios et al., 2011). For example, for functional dairy products, carriers are very effective in influencing consumers' perceived healthiness. In general, the effect is positive when a "natural" match between the carrier and the bioactive ingredient exists, whereas the effect is negative for "unnatural" matches, such as omega-3 added to yogurt (Bimbo et al., 2017). Taste and price quality ratio are important factors in consumers' choice of Ffs (GajdosKljusuric, Cacic, Misir, & Cacic, 2015). Product's brand, packages' features and convenience affect positively consumers' choices for functional food products (Urala & Lähteenmäki, 2003). Finally, health claims play an important role in informed purchase decisions. In particular consumers are more interested in FF with health promoting claims than in disease risk reduction claims (Lahteenmaki, 2013; Van Kleef et al., 2005).

3.2. Novel foods

Recent innovations in food sector led to a considerable increase in the number of new foods entering the market and creating a climate of insecurity for consumers (Bäckström, Pirttilä-Backman, & Tuorila, 2004). The rejection that some people show towards new or unfamiliar foods, a phenomenon known as neophobia led to a very high new product failure rate, around 70–80%. Food neophobia is defined as the tendency to avoid new foods and it depends on three main reasons: aversion, danger and disgust. In consolidated scientific literature, neophobia is evaluated with measuring scales (Pliner & Loewen, 1997), or by conducting food preference tests and experiments involving unfamiliar foods (Pliner & Loewen, 2002).

The consolidated evidence showed that the willingness to try an unfamiliar food depends strongly on information on the taste and on the nature of food (Nordin, Broman, Garvill, & Nyroos, 2004). Socio-demographic variables also play an important role: age (Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001), gender (Nordin et al., 2004) and place of residence (Flight, Leppard, & Cox, 2003; Tuorila et al., 2001) influence the acceptance of novel food. Younger people living in urban center show a lower interest in traditional food. Few studies

analyzed consumers' preference regarding novel food (Mattson & Helmersson, 2007). The results showed that consumption decisions regarding novel food products have an important emotional component that is more pronounced in neophobic subjects.

In order to protect public health by ensuring food safety directive that requires food safety assessments of traditional foods for pre-market approval, the European Union Regulation defines "novel food" as food or food ingredients that were not used for human consumption to a significant degree within the EU before 15 May 1997 (EU Regulation, 1997). It includes: a) foods and food ingredients with a new or intentionally modified primary molecular structure; b) foods and food ingredients consisting of or isolated from micro-organisms, fungi or algae; c) foods and food ingredients consisting of or isolated from plants and food ingredients isolated from animals, except for foods and food ingredients obtained by traditional propagating or breeding practices with a history of safe use; d) foods and food ingredients to which a production process not currently used has been applied, where that process gives rise to significant changes in the composition or structure of the foods or food ingredients which affect their nutritional value, metabolism or level of undesirable substances. The EU regulation, originally intended to establish an internationally harmonized framework for safety evaluation regulation, establishes for the first time within Europe a mandatory premarket evaluation and approval for such foods (Huggett & Conzelmann, 1997). A critical focus of scientific research in the latter area has been the study of factors responsible for consumer choice, purchase behavior, and acceptance of these foods. The intrinsic and extrinsic factors, the drivers and barriers that influence consumer acceptance of novel foods, the cognitive expectations that consumers have regarding the sensory and hedonic characteristics of foods are factors of actual interest for researchers (Barrena, García, & Sánchez, 2015; Barrena & Sánchez, 2013; Hobbs, Ashouri, George, Lovegrove, & Methven, 2014).

In the last few years, public and scientific interest in novel food from insects is growing (Tan et al., 2015). In fact, in recent years edible insects have attracted much interest in Western population due to their nutritional and environmental advantages. The high healthy value of diet based on insects is due to the low content of saturated fatty acids, the high digestibility and the presence of Omega 3 (Rumpold & Schlüter, 2013). In addition insect-based food could produce good environmental benefits because of the relevant reduction in carbon emissions (van Huis et al., 2013), the lower requirements of water and space, and moreover, the better biomass conversion rate (Van Huis et al., 2013). As a consequence, the high nutritional value with the high environmental sustainability and the high production value make these novel food of great interest for human nutrition all over the world (Van Huis et al., 2013).

Despite the benefits, many studies showed a strong scepticism of western consumers towards the introduction of food with insect-based ingredients, especially in that countries where insects are not traditionally considered to be food (Vanhonacker et al., 2013; Verbeke, 2015). Several authors analyzed the consumers' behavior towards the consumption of insect-based food, exploring the main barriers and the potential drivers for this novel food products (Caparros Megido et al., 2014; Verbeke, 2015). The main findings reveal that cultural background and individual experiences play an important role on consumers acceptance, that consumers are higher willingness to eat the processed insect-based foods compared to the unprocessed foods; that the social acceptance for these new foods is higher when consumers had experience with insect food and when they are incorporated into familiar food items (Hamerman, 2016; Le Goff & Delarue, 2016), that the type of communication influences the willingness to eat insect as food and that emotional effect deriving from the view and the contact of the insect product influence the willingness to try it in order to reduce the impact of these foods out of our cultural framework (Baselice, De Devitiis, Nardone, Stasi, & Viscecchia, 2016). Further studies are required to better explore the barrier of prejudices towards insect food and to

reduce the visual impact in order to improve the willingness to accept and buy this novel food.

3.3. Nanotechnologies

A number of engineered nanoparticles have been already developed for a variety of applications in the food sector and they are expected to provide a range of important benefits including sensory improvements, increased absorption of nutrients, stabilization of bioactive compounds, extended product shelf-life, quality and safety monitoring (Dasgupta et al., 2015; Handford et al., 2014; Pathakoti, Manubolu, & Hwang, 2017; Ranjan et al., 2014; Rossi et al., 2014). Two main types of nanotechnology food applications are distinguished: “nano-inside” applications when nanoparticles are incorporated into the food product, and “nano-outside” applications when nanoparticles are incorporated into the food contact materials like packaging (Handford et al., 2014; Pathakoti et al., 2017).

However, most of potential nanotechnology applications in the food sector are still at the early stage of product development, and only a limited number of “nano-outside” applications are already commercially available (Handford et al., 2014), even though it is really difficult to make a complete inventory of nanotechnology food applications already commercialized in the global market.

The most important factor that limits the diffusion of nanotechnology applications in the food market is the existing scientific gaps in knowledge about their potential risks for human health and environment. More precisely, while toxicology studies are providing increasing evidence that engineered nanoparticles may have adverse effects on human health and environment, knowledge about the assessment of environment exposure to engineered nanoparticles is still limited. In addition, because toxicity is specific for different nanoparticles, a safety and environmental assessment must be performed on a case by case basis (Handford et al., 2014). Recent evidence do not allow to build a sound science-based regulatory framework, and thus there are currently no specific regulations on nanotechnology food applications either in EU, USA or elsewhere (Coles & Frewer, 2013; Magnuson et al., 2013). In addition, there is a lack of universal guidelines specifically developed for the safety and environmental assessment of nanotechnology food applications, even though experts from around the globe are working in bringing an international dimension and harmonization to “nanometrology” and standardization of approaches (Magnuson et al., 2013; Schoonjans & Chaudhry, 2017). However, the current lack of clear governance framework and consequent regulatory uncertainty makes it difficult for developers and manufacturers to know what, if any, regulations should be complied with, and what risk assessments, if any, are appropriate.

Another potential barrier to the commercialization of food nanotechnology products is related to public concerns about the use of such novel and unfamiliar technology with consequent uncertainty of consumers' acceptance. Several studies have been carried out in different countries (Bieberstein, Roosen, Marette, Blanchemanche, & Vandermoere, 2013; Chen, Lin, & Cheng, 2013; Cook & Fairweather, 2007; Farshchi, Sadmezhaad, Nejad, Mahmoodi, & Abadi, 2011; Matin et al., 2012; Schnettler et al., 2013) to investigate public awareness and attitude towards food nanotechnologies. Results of these studies show that public knowledge about food nanotechnology, in general, is very limited and attitude varies between individuals. As expected, attitude towards nanotechnology food applications is influenced by the associated perceived benefits and perceived risks (Chen et al., 2013). Consumers' perception of risks and benefits is, in turn, mainly determined by general attitude towards new technology (neophobia/neophilia), nanotechnology knowledge, and social trust (i.e. trust in scientists, regulatory agencies, food industry and retail) (Chen et al., 2013; Cook & Fairweather, 2007; Matin et al., 2012). Specifically, a positive attitude towards new technology (neophobia), a better knowledge of nanotechnologies, and a higher social trust tend to increase consumers' perceived benefits and to reduce

consumers' perceived risk: this, in turn, increase consumers' willingness to buy food with nanotechnology applications (Viscecchia, De Devitiis, Carlucci, Nardone, & Santeramo, 2018). Finally, consumers' acceptance of food nanotechnology varies among different applications and, in particular, it is greater for “nano-outside” applications which are not ingested and thus are associated with perception of minor hazard.

Therefore, the successful introduction of nanotechnology applications into the food market is strictly related with the process that should follow the advancement of toxicology research and consequent construction of a sound science-based regulatory framework as well as the increasing public knowledge, awareness and trust in order to avoid the same problems that occurred with previous new food such as GMOs.

4. Conclusions

The role of attributes associated to food safety, as well as the relevance of the labels and packaging have been reviewed. Both in the F & Vs sector and in seafood markets, the use (and the relevance) of certifications and labels as a market tool to build trust among consumers and producers is a clear trend, and it is likely to expand in the near future. The meat industry is not exempt by these dynamics, whereas it has been showed that increasing attention is devoted to sustainability issues, environmental efficiency, and animal welfare. As for the innovations in the food industry, it has been recognized that further studies are required to explore consumers' attitudes towards novel and functional foods and, in particular, studies should be conducted in Countries for which consumers' attitudes and preferences are still weakly investigated. Lastly, it is shown that nanotechnologies are still not much spread. In this case more effort should be devoted to establish a science-based regulatory framework as well as to increase public knowledge, awareness and trust in order to facilitate the transition to a more advanced food industry. Through the selected case studies, the main changes at global level of the food industry have been presented. The food industry must face consumers' expectations and global challenges such as the need to ensure safe food, while keeping in mind the global sustainability. A challenge for the industry is to orient consumption towards food that are sustainably produced. In addition, the global sector should be more oriented towards the protection of the environment, the preservation of the natural resources, in order to facilitate the emergence of strategies able to promote the circular economy and to reduce food wastage.

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