Active Ageing and Healthy Living
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Food for Healthy Living and Active Ageing

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Abstract. The link between diet and health has been recognized since the Grecian period; as Hippocrates said, "Let food be your medicine and medicine be your food". Although the primary goals of diet are meeting nutritional requirements and providing energy, there is increasing awareness that a correct and balanced diet may prevent the insurgence of diet-related pathologies and/or improve well-being and life expectancy, also reflecting on the ageing process. Research on the interaction among nutrients, gut microbiota and host metabolism is presently unravelling the molecular mechanisms underlying the positive and negative effects of traditional diets on health and ageing, providing useful information for the design of innovative foods targeting specific needs and segments of the population. The food supply chain plays a key role in ensuring quality and safety through both comprehensive quality management and inspection systems and a focused innovation process mainly devoted to the creation of functional foods. However, innovation and scientific development pose a problem of information asymmetry towards final consumers; thus, regulatory aspects and private and public communication strategies must be efficiently developed.

Keywords. Diet, Food, Innovation, Research, Communication, Elderly, Health

Introduction

Europe is growing older. To remain fully independent and actively engaged in their communities, elderly people (aged over 60 years [1]) must address physical and psychological changes that reduce their efficiency and often their well-being. With age, organs and apparatuses (e.g. bones, muscles, cardiovascular and respiratory systems) become progressively impaired and cognitive abilities decrease. Body composition also changes. Muscle mass, body density, immune function, nutrient absorption and metabolism decrease, and nutrient requirements vary accordingly. These changes, together with environmental and socio-economic factors, affect the lifestyle of individuals. In this context, a proper diet contributes to preventing the onset of a

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number of age-related diseases and fosters healthy, active ageing and a longer life (Figure 1).

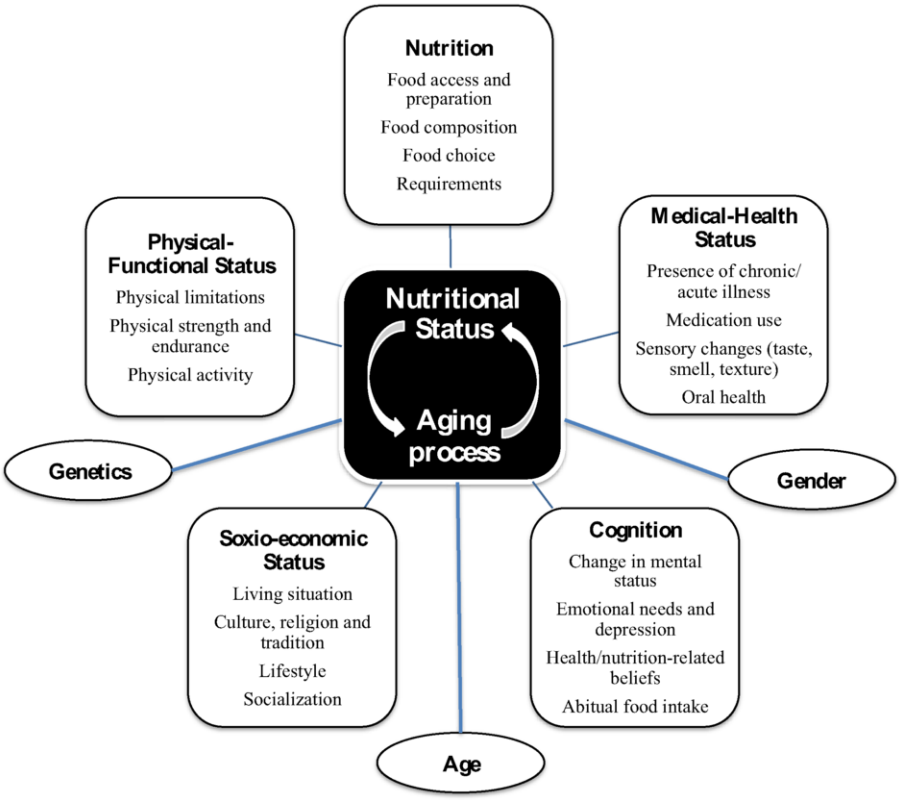

Figure 1. Factors that influence the nutritional status during ageing ([1] modified).

Ageing people often suffer from either reduced food and water intake due to economic, psychological and physical distress, such as depression, digestive health problems and sensory changes [2] or from a monotonous and unbalanced diet, e.g. high in energy and lacking high biological value proteins, minerals and vitamins (Figure 1). These, combined with reduced physical exercise, increase the risk of premature ageing symptoms and syndromes (e.g. metabolic syndrome and diabetes).

The link between diet and health has been recognized since the Grecian period. For a long time, the scientific community has investigated this topic, mainly focusing on the effects of and recovery from a deficiency of specific essential nutrients and on the consequences for metabolism of an excess/deficiency of large categories of nutrients (e.g. carbohydrates, lipids, proteins; [3]). Only recently have research teams taken to the forefront of research the concept that nutritional well-being is a fundamental component of human health [4]. As a consequence, research in food science addressed to human health has increased exponentially and in recent years thousands of papers on this topic have been published in peer-reviewed journals, many of them addressing the needs of the elderly.

In the third millennium, publication of the human genome project and the consequent development of high-throughput molecular tools in human and model species have opened new roads for investigating the effects of diet and nutrients on metabolism, funding the new science of nutrigenomics and boosting the collection of new knowledge in the field [5].

Despite a number of important discoveries regarding the intake of saturated and trans-unsaturated fatty acids and cardio-vascular diseases [6], energy intake, oxidative stress and cancer [7] and the protective effects of fruits and vegetables on cancer [8], research has so far only scratched the surface of the complex relationships between diet and human health, well-being and quality of life. Complexity arises from the genetic variation in individuals, variation in nutritional requirements with age and health status, variability of food in terms of nutrient components and safety and to the intriguing and still under-investigated role of the gut microbiota as mediator between nutrients and human metabolism [9]. In short, much is still to be discovered and an internationally coordinated and multidisciplinary research effort is needed to shed light on the full potential of nutritional strategies for the improvement of human health and well-being in populations of different ages. This has particular importance for older adults, who have life conditions that are more critical. As Hippocrates said, “Let food be your medicine and medicine be your food”.

1. Consequences of insufficient, unbalanced or excessive diet

Malnutrition is defined as a state of deficiency, excess or imbalance of energy and nutrients. It causes adverse effects on body form, function and clinical outcomes [10] and it is recorded at increasing frequency in the elderly. About 16% of people aged 65 or older and 2% of people aged 85 or older are classified as malnourished [11]. The prevalence of malnutrition is increasing in Westernized populations and is often associated with a decline in functional status, impaired muscle function, decreased bone mass, immune dysfunction, anaemia, reduced cognitive function, poor wound healing, delayed recovery from surgery, higher hospital readmission rates and mortality [12]. Overall, the aetiology of malnutrition for older people can be considered multifactorial [13]. In particular, it is hypothesized that a common mechanism exists at the origin of the main pathologies associated with ageing (e.g. Alzheimer's, Parkinson's, type 2 diabetes, atherosclerosis), in which free radicals trigger an inflammatory process through oxidative stress. The elderly’s immune system is in fact characterized by deregulation of the inflammatory processes with a reduction in longevity through mechanisms of accelerated immune-senescence and chronic inflammation [14]. Nutrition can exert a significant influence in the control of these phenomena.

Undernutrition is frequently not recognized in the community, and in older persons in particular [15]. Older people often have reduced appetite and energy expenditure. Coupled with a decline in biological and physiological functions such as reduced lean body mass, changes in immune response and hormonal level, as well as changes in fluid electrolyte regulation, the reduced appetite and energy expenditure delay gastric emptying and diminish the senses of smell and taste [13].

Overnutrition is also a critical problem in older people [13]. The prevalence of overweight older people in Westernized countries is increasing. In 2000, 58% of US citizens aged 65 years had a body mass index (BMI) of 25 (normal BMI values range between 18.5 and 24.99), and the prevalence of obesity (BMI over 30) in the US

increased by 36% from 1991 to 2000 [16]. Since a high BMI is associated with conditions such as diabetes, hypertension and cardiovascular disease, the risk of death in older people with high BMI increases. Also, older people with high BMI suffer from symptomatic osteoarthritis, increased rate of cataracts, mechanical urinary and bladder problems and sleep apnoea and other respiratory problems [17]. Intentional weight loss through correct diet management by overweight older people is highly advisable. However, diet should be combined with a physical exercise program to preserve muscle mass, which decreases rapidly in the elderly.

2. Diet in old age

A healthy balanced diet for the elderly should match the physiological needs of old age and hence contribute, together with an active lifestyle, to a long and healthy life.

In the case of undernutrition, nutrients most often deficient in the diet of older people are vitamins (especially A, C, thiamine, riboflavin and pyridoxine) and some minerals (calcium, iron and zinc). Sometimes protein intake is also insufficient.

Ageing is also partially caused by oxidative damage to cells and tissues. In addition to contributing to the disease condition, the severity of this oxidative challenge is directly proportional to food intake and food quality. However, some foods (functional foods) contain antioxidant and bioactive components that help in reducing oxidative stress and preventing some diseases, e.g. cardiovascular diseases, and some types of cancer. Nevertheless, the recommended antioxidant-enriched diets (e.g. with vitamin E, polyphenols) are sometimes ineffective [18], indicating that knowledge about the mechanisms of action of many nutrients potentially affecting longevity and active ageing is still incomplete.

One of the most debated aspects of elder nutrition is protein undernutrition or malnutrition. This is frequently caused by reduced animal product consumption and age-related conditions such as tooth loss, reduction of taste and smell and diseases that affect the gastro-intestinal tract. The demand for protein increases in the case of febrile diseases, burns, bedsores and fractures and also after surgery. Dietary proteins play a vital role in maintaining homeostasis, muscle mass, skeletal integrity and a reactive immune system. Reduction in muscle mass in the elderly may be partially prevented by adequate protein intake and physical activity. In a balanced diet the protein should be both of animal and plant origin.

Even if ageing induces a progressive increase of glucose intolerance, carbohydrates remain the main source of energy in the diet (at least 50% of daily needs). In the elderly, despite a general decline in taste sensitivity, a sweet taste is appreciated and associated with good sensations and feelings as well as enjoyment and pleasure. High-carbohydrate foods are also easy to chew and, therefore, are preferred by the elderly.

However, ageing is also associated with an increased risk of insulin resistance, metabolic syndrome and diabetes. The consumption of low glycemic index (GI) foods and an increase in resistant starch (RS)[2] daily intake help in controlling these risks. In fact, the consumption of low GI foods has been related to reductions in the risk of

[2] RS is the "the fraction of ingested starch that escapes enzymatic digestion by endogenous enzymes in the upper gastrointestinal tract and passes into the colon where it can be fermented by caecal and colonic microbial communities"

coronary heart disease and type 2 diabetes [19]. Metabolic studies have also revealed that replacing high-GI carbohydrates with low-GI sources improves glycemic control and reduces hypoglycemic episodes [20], as foods rich in RS fraction.

Fat must be included in a balanced diet for the elderly to provide essential fatty acids needed for maintenance of the organism. To satisfy these requirements, fat should be included to provide 2% to 6% of total calories. Essential fatty acid content is low in lipids of terrestrial animal origin, while sea foods and some plant products (e.g. olive oil) are much better sources. Dietary fat, whose primary function is to provide energy, is also necessary to absorb fat-soluble vitamins: A, D, E and K. Minerals and vitamins are chemical compounds needed in small amounts (micronutrients) in many biological processes. Therefore, a healthy diet for the elderly should provide adequate amounts of minerals. Finally, a shortage of water-soluble (rapidly excreted) and fat-soluble (slowly excreted) vitamins causes severe hypovitaminosis syndrome at all ages.

Assessment of diet quality for the elderly (including amount consumed) is the first step in planning corrective interventions. Correct information and education on the advantages of diversification in food consumption, inclusion of functional foods in the diet and an active lifestyle are urgent needs because they hold the potential to decrease the risk of occurrence and the severity of many chronic diseases of the elderly and to improve their quality of life.

3. Tradition and innovation for better food

Through the centuries, Italian cuisine has developed worldwide recognition for high quality, simplicity in cooking and ease in preparation. In 2013, CNN ranked Italian cuisine as the best in the world (http://travel.cnn.com/explorations/eat/worlds-best-food-cultures-453528). However, Italians' ability to use their traditional recipes as starting points for innovation in food is not always apparent.

Pizza, one of the most popular Italian foods throughout the world, may be an example. Pizza ingredients are very simple: flour, water, a little bit of salt, olive oil and another essential ingredient, tomato sauce. The first known reference [21] to the term "pizza" appears far earlier than Columbus travelled to the Americas, in a Latin text dated 997 AD, probably the *focaccia,* a flat bread known since ancient Roman times as *panis focacius* to which toppings were added but, obviously, no tomatoes.

The tomato arrived in Europe from the Americas in the 16th century, but it was believed to be unhealthy. However, by the late 18th century, it was common for poor people in the area around Naples to add tomato to their yeast-based flat bread. The innovation that turned flat bread into pizza was the use of tomato (a *novel food* at that time) as a topping, in a recipe that stems from ancient Rome.

This process of turning traditional foods into something new still holds today; according to statistical analysis of the website www.gopubmed.org, Italy is ranked very high among the countries publishing research papers in the area of functional food (see Figure 2a). Italy scores an even better ranking in the area of scientific research dealing with human ageing (see Figure 2b).

Accordingly, one of the main topics of Padiglione Italia, the Italian pavilion in EXPO Milan 2015 (the universal exposition with the theme "Feeding the Planet, Energy for life" focused on agriculture, food and nutrition) deals with traditional foods and excellence in Italy. This topic points out the evolution of the Italian food industry, which is exploiting the traditional food to promote a better and healthier life.

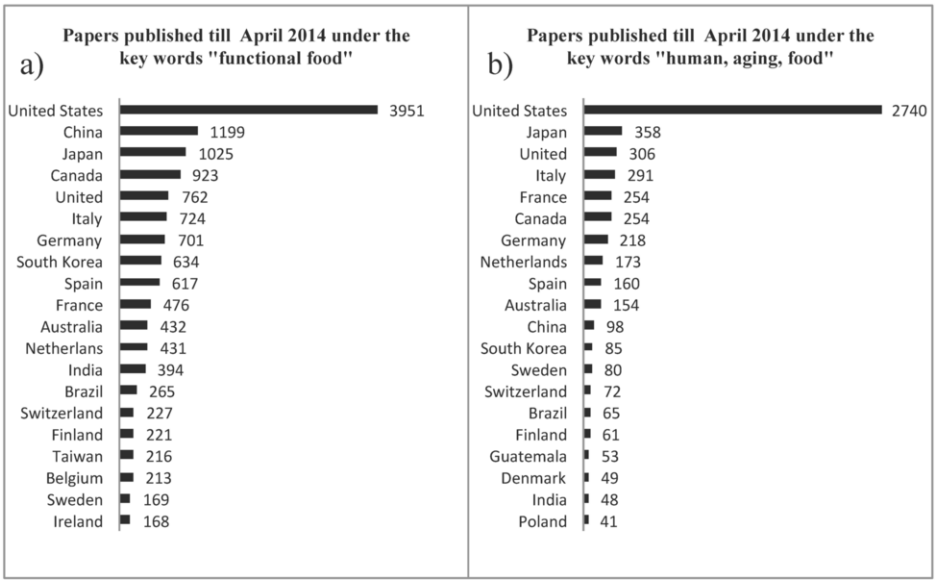

Figure 2. Papers published through April 2014 under the key words (a) "functional food" and (b) "humans, ageing, food" (source:www.gopubmed.org).

The quest for better food capable of promoting a healthier life is therefore a strategic research area for a country in which eating is a substantial component of the life style. This research must be multifaceted to address the four Ss related to food production and consumption: i) Security; ii) Safety; iii) Sustainability; iv) Socio-cultural components.

Several challenges in Europe are associated with these four Ss; climate changes are endangering our crops and food losses related to bad weather are increasing. In the meantime, it is mandatory to maintain a very high level of food safety with a minimal use of chemicals; a simple example is the ban, active from 2006 in European Union (EU) countries, on antibiotics as growth promoters in livestock. The ecological impact of the food chain must be reduced without reducing the production potential.

In addition, the exploitation of certain foods in supporting health, the so-called functional foods, may play a role in the European society of the third millennium by establishing a new role for food. European food companies have developed health-supporting ingredients (e.g. cholesterol-controlling phytosterols) and since 2006 the EU has regulated food health claims. If supported by synergic efforts of research, industrial development and regulations able to support innovation, this scenario may open an exciting range of opportunities for the EU.

4. The health role of "innovative" PDO products

Some traditional foods are well known for their excellent taste and, in many cases, as sources of important nutrients, although they can also contain less desired components, such as cholesterol and saturated fatty acids. PDO cheeses are good examples: they are

good sources of high-quality protein and minerals, like calcium, but have a high content of cholesterol and saturated fatty acids, nutrients considered less positive due to their relationship with cardiovascular diseases.

In recent years, the discovery that some milk peptides have a positive effect on blood pressure [22] boosted research on the effect of cheese consumption on controlling hypertension. The consumption of small amounts (30 g/day) of Grana Padano cheese significantly reduced systolic blood pressure compared to a diet with the same sodium content but lacking Grana Padano [23]. Sour milk-enriched milk anti-hypertensive peptides also produced positive effects [24]. Specific strains of *Lactobacillus helveticus* increase the content of these peptides in cheese during fermentation, thus increasing the nutritional value of a PDO cheese without altering the traditional hand-making process of this dairy food. Although the positive effect on human health of probiotic bacteria included in fermented milk is still not recognized by the EFSA, the potential of this approach to improve gut health remains high.

The positive effects on human health of eating whole grains has been acknowledged for a long time; however, in recent years, research has demonstrated that pasta and bakery products enriched with specific fiber fractions (β-glucans, arabinoxylans) reduce glycemic index and positively modulate human gut microflora [25].

Other technological processes can be used to increase the content of resistant starch, a very slowly digestible carbohydrate fraction that has a positive effect on human health. As a matter of fact, resistant starch reduces the rise in blood glucose after a meal and can act as a prebiotic fiber. The RS content in food can also be increased with technological processes (e.g. retrogradation after cooking or chemical reaction with organic acids) or by using ingredients naturally rich in RS (native amylose-rich starch).

Improvements in livestock hygiene and adoption of bacterial culture starters have sharply reduced the use of nitrate and sodium chloride (NaCl) in the manufacturing of typical Italian PDO salami. Since nitrate is a risk factor for colorectal cancer and excessive sodium intake increases the risk of blood hypertension, improvement in the nutritional value of cured pork meat is evident.

The pork fatty acid profile has also changed in recent years. The amount of saturated fatty acids (SFA) and cholesterol has decreased and the quantity of poly-unsaturated fatty acids (PUFA) is becoming closer to the most up-to-date dietary recommendations.

Advances in animal breeding and nutrition are now producing eggs, milk and meat with less cholesterol and SFA, more PUFA, more conjugated linoleic acid (functional molecule produced naturally during the rumen fermentation) and higher content of antioxidant molecules (e.g. vitamin E).

Therefore, innovation derived from the application of research output produces novel food, but also greatly benefits traditional food, maintaining the taste and culture and improving health.

5. The economic role of PDO products

The adoption of innovative production techniques in the area of PDO products, targeted to improving their health-enhancing properties, can also be a winning strategy from an economic point of view. In fact, the role of PDO and protected geographical indication

(PGI) products in the Italian agro-food system is crucial and the above potential health-related innovations may bring large economic benefits to all actors in the supply chain.

Italy is first among EU countries in number of PDO-PGI registered products (262 in 2013, with 25 new applications under evaluation), as well in terms of total market sales [26]. In fact, in 2012, the turnover for PDO and PGI products in Italy amounted to around 7 billion euros at the wholesale level (+2.1% with respect to 2011) and 12.3 billion euros at the retail level (+5%). At constant prices, production volumes increased 5.3% in 2012, with stronger growth rates for fruits and vegetables (+7.2%) and cheeses (+5.5%). Exports of PDO-PGI products accounted for almost 30% of total turnover (2.1 billion euros at wholesale prices) and increased by 4.8% in 2012, much more than domestic consumption (+0.8%). Thus, while the Italian economy was experiencing the worst economic crisis since World War II (the GDP fell by 2.5% in 2012), the market trend for PDO-PGI products was clearly countercyclical, especially for exports, signaling that despite the crisis consumers are sensitive to the quality of what they eat.

The above market data, which were collected according to the classification of the European Commission (EC), do not include wines. In Italy, adding PDO/PGI wines implies doubling the figures above (i.e. the total turnover reaches 14 billion euros), but in this case France becomes the leading EU country in terms of market size.

The peculiar feature of the Italian PDO-PGI market is that, while most PDO-PGIs are niche products (as is the rule in other EU countries), some key products are actually consumed by a very high proportion of Italian households (in some cases, above 90%) and their turnover is extremely relevant in absolute terms. This is especially true for dairy and meat products, which account for 59% and 37%, respectively, of the total PDO-PGI turnover. More specifically, the first six PDO-PGI products account for almost 80% of total turnover (i.e. 5.6 billion euros at the wholesale level) and their production involves a huge number of farmers and processors. These products (i.e. Prosciutto di Parma, Prosciutto di San Daniele, Grana Padano, Parmigiano Reggiano, Gorgonzola, Asiago) can be considered mass market goods since they reach final consumers mainly through super and hypermarket chains, rather than through specialised shops and, given their incidence in food retail sales, they are a key element of large retailers' offerings.

In this market context, improving the health-enhancing properties of PDO-PGI products while maintaining their traditional handcrafted features certainly offers an attractive opportunity for the Italian agro-food system. In fact, several studies in recent years have shown that consumers are willing to pay a price premium for functional foods (see, among others, [27]), as well for products of certified origin (see, among others, [28]). This means that producers may benefit from such improvements in health-related attributes, as long as the unit cost of production does not increase more than the potential price premium. Moreover, producers must count on a fair distribution of the value added along the chain since recent studies have shown that for the most important PDO-PGI products retailers may exercise some form of market power toward processors as well as consumers [29].

6. Communication

Innovation and scientific development strengthen the problem of information asymmetry towards final consumers; regulatory aspects and private and public communication strategies must be efficiently developed [30]. Thus, understanding of

the determinants and mechanisms by which information is conveyed to and processed by consumers plays an important role in any communication strategy. Indeed, communication is not always the best option available; policy makers may resort to other instruments, such as taxes (e.g. a fat-tax) and subsidies or standards.

Although, the EU is the area in the world with the lowest incidence of foodborne diseases, it is unavoidable that to any food consumption is associated a risk for consumer health. Food risk is the consequence of a hazard in food. A *hazard* is a biological, chemical or physical agent that may be responsible for a health problem (i.e. a contaminant), while *risk* is related to the probability of the consumer incurring a problem related to the hazard. As a consequence, food risk is associated with the level of consumption of the *risky* food and thus to habits and lifestyles. The main international organisations (the Food and Agriculture Organisation and the World Health Organisation through the Codex Alimentarius) developed a protocol for risk analysis which is also applied by the European Union after the food crises of the late '90s. Risk analysis is a three-step procedure that includes *risk assessment*, *risk management* and eventually *risk communication*.

The *risk assessment* is a scientific process, and in the EU it is coordinated by EFSA, which collects the body of scientific knowledge, estimates the food-associated risks and provides scientific support to policy makers. The EFSA has defined five categories of risk: none/negligible, low, medium, high, and unknown. Neutrality and scientific excellence are guaranteed by the scientific panels, made up of independent researchers from universities and research centres. Since 2002, the EFSA has produced more than 2,400 scientific opinions. The EFSA is also involved in the approval of nutrition and health claims, including those concerning functional foods, under Regulation (EC) 1924/2006.

Risk management refers to the process of defining intervention measures with the objective of reducing the risk to the *as low as reasonably achievable* (ALARA) level, ensuring the consumer an *adequate level of protection* (ALOP); economic issues, life styles, consumption behavior and technical aspects are also considered. The European approach to risk is largely founded on the so-called *precautionary principle* (Article 191 of the Treaty on the Functioning of the European Union), which states that when scientific evidence is not conclusive, a rapid and drastic response, including a complete ban and/or withdrawal of a product from the market, can be undertaken. Furthermore, to make the process of risk management more efficient, the Rapid Alert System for Food and Feed (RASFF) was established within the EU.

Risk communication is the process of informing the public; communication regarding food risks must be transparent, consistent, not alarmist, appropriate and easily accessible. The risk is not always clear, and uncertainty should be acknowledged, together with the steps undertaken to address the uncertainty. Thus, communication should raise awareness in consumers and spread the results of the EFSA's scientific work, assisting consumers in reaching informed judgments. Unfavorable or negative information is normally weighted more heavily than favorable information. Unfavorable information usually produces a rapid change in behavior, while the recovery, if ever possible, is often slow. Also conflicting messages, mainly when experts change their advice, augment consumers' uncertainty and hamper their decision-making process.

Communication may influence individual behavior. Changing behavior is a complex and multidimensional process that results from the interaction of personal (e.g. attitudes, norms, education, beliefs) as well as socio-economic and environmental

factors. It will then depend on the way information is conveyed (e.g. communication media) and the way consumers process it. From consumers' perspective, information is required to improve their well-being; consumers ask not only for quality, safety, pleasure, nutritional content, but also for environmental, ethical, social and technical conditions of production and processing (e.g. organic production, place of origin, fair trade). Product innovation may be a profitable strategy, and communication plays a key role in increasing and maintaining reputation (i.e. brand image) and consumers' trust.

Information theory treats communication as a process in which a sender communicates to a target, and feedback will depend on the way information is processed; this simplified scheme should be integrated with other elements from consumer psychology and behavioral models that will help in understanding the stages (hierarchy) by which consumers respond to information. Consumers' processing of and reaction to perceived information are not conducted in a rational manner. Thus, it is necessary to employ both analytical and cognitive processing and simple decision rules with low in-deep treatment and the use of external clues, such as trust in the information source.

Consumers seek information on the most common media (newspaper, television, internet, social media), but also referring to direct contacts with acquaintances. More information does not necessarily translate into more informed consumers. An excess of information may induce consumers to discard it, thus making it ineffective and useless; consumers often pay attention to just a few cues (brand image, price, origin). Subgroups of the population may react differently to communication strategies relating to food safety/risk and health issues. Specific care should be devoted when vulnerable groups (e.g. children, elderly, pregnant women) are the target of the communication. Communication can be further complicated by age. The elderly constitute a largely heterogeneous group due to the very wide range of experiences that may affect their perceptions. As previously stated, the proportion of elderly in the population is increasing and the elderly constitute a vulnerable segment of the population in terms of health, economic status, cognitive abilities and access to information.

As a result, information on food issues for the elderly must be conveyed in a specific way. Some traditional media channels may have low direct relevance (e.g. internet and/or social media); in addition, information processing may be hampered in the elderly. Thus, beyond traditional media, communication of information should favor indirect routes, mainly through primary care physicians, younger relatives and care-givers. A successful strategy for food diet enhancement in the elderly must include tailored communication and education interventions for care-givers, together with other policy instruments acting on psycosocial factors.

7. Conclusions

Although food availability and use have relevant country-specific aspects, many drivers and issues related to elder malnutrition are common across Europe and call for intensification of a coordinated international and interdisciplinary research effort to address the four Ss related to food production and consumption:

Food Security:

- Increase crop and livestock resiliance to climate changes, particularly to drought and high temperatures.

- Decrease food losses and wastes along the production chain, from farm to fork.
- Grant access to proper food at a just price.

Food Safety

- Maintain a very high safety level of food of animal and plant origin, with minimal use of chemicals.
- Exploit functional food in supporting health.
- Understand the relationship between diet and health in old age, with particular attention to malnutrition, foodborne infections intoxications and degerative diseases.
- Unravel the relationship between diet and longevity and identify individual nutrients responsible for the effects observed.
- Explore new tools provided by modern technologies and suitable cell and animal models to shed light on the complex interaction between diet and health, particularly in old age.
- Understand the interactions between gut microbiota and the host genome, metabolism, inflammation and immune response.

Food Sustainability

- Reduce the ecological impact of the food chain without reducing productivity.
- Estimate the consumers' price premium for "innovative" PDO-PGI products.
- Evaluate the potential impact on farmers' and processors' profits of introducing health-related innovations in PDO-PGI production technologies.
- Analyze the role of market power in the PDO-PGI supply chain to reach a fair distribution of the value added among the actors of the chain.

Food as Socio-Cultural Component

- Improve the synergic efforts of research, industrial development and regulations able to support innovation.
- Design diets suited to elder needs as a function of lifestyle and health status.
- Define communication means aiming to educate the elderly in food choices that promote a long, active and healthy life.

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