Food Design: Quality matters!

Professor Vincenzo Fogliano

Inaugural lecture upon taking up the post of Professor of
Food Quality & Design at Wageningen University on 1 May 2014

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Rector Magnificus, esteemed colleagues, families and friends,

Thank you for coming here to attend my Inaugural lecture upon taking up the position of chair of the Food Quality & Design (FQD) group. Today I would like to make with you a short journey across the past, the present and the future of food design, which is a discipline having behind a broad science covering all the aspects underneath the ideation, creation and development of food products.

Along human history, the advancements in food handling has been usually determined by technical innovations. With the discovery of fire many new food preparations became possible and with the invention of cutting instruments our ancestors became able to chop meat and roots into small pieces. Later on, the development of pottery allowed the storage of liquids and this was one of the key steps to enter the Neolithic era.

The following developments of food handling were driven by one main goal: to avoid the spoilage of the edible material that exceeded the possibilities of immediate consumption. From this viewpoint, delicious cheese as well meat and fish derivatives were only effective technical solutions to store milk, meat and fish allowing human survival during the long periods of food shortage.

Later on, the use of spices to preserve food from spoilage was discovered: along the centuries the issue of food storage was so important that a great part of the commerce flourishing after Medieval age and making the fortune of Italian and Dutch merchants, was promoted by the increasing demand of spices like black pepper, cinnamon, ginger and cloves.

The beginning of the modern era for food science was initiated by Nicolas Appert with the invention of the sterilization procedure. The "Appertization" paved the way for the development of canning industry and made available, at reasonable price, a variety of long shelf life products. The recent introduction of refrigeration and the modern transportation systems completed this transition and rapidly led us to the present situation with a wide availability of any type of food products in megastores all around the world. Nowadays only socio-economic and political reasons prevent them from being accessible to everyone.

In Figure 1 the immediate feeling of the shift occurred in people possibilities is illustrated: while in ancient markets consumers could only take available commodities, now most of them can choose exactly what they want among an enormous variety of products.

Figure 1. Left: traditional market in transition countries. Consumers can take only few available items which means little power to consumer. Right: in a modern supermarket consumers have a strong decision power.

The main drivers of the consumers' decision are price, pleasure, convenience and, particularly in the last years, also healthiness and it is on the healthy food design that I will focus the first part of my talk.

The proper development of a food product should take into account all the quality parameters that will contribute to its identity and consequently to its success, therefore it is a very complex matter. To tackle this issue at FQD group the food chain approach was developed: the example of broccoli chain is shown in Figure 2.

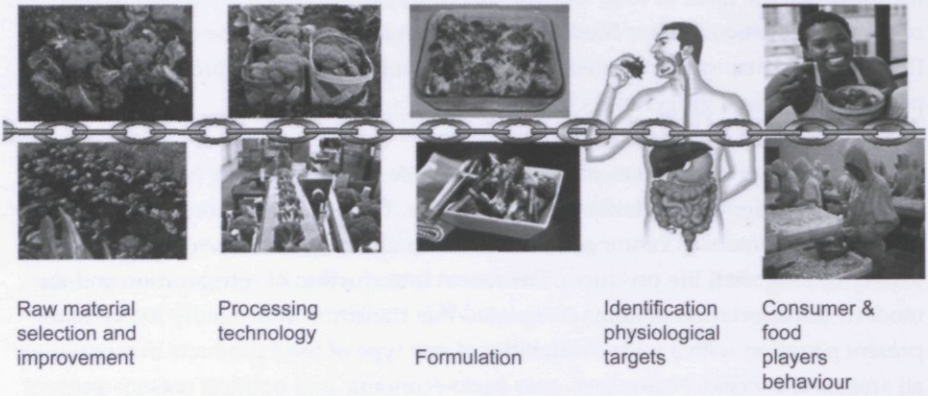

Figure 2. The Food Quality & Design chain approach applied to the case of broccoli.

With this strategy the various steps of product development, starting from the selection of raw material through the definition of suitable processing and the possible formulation, can be segmented and combined with several human factors such as the physiological effects in our body, the consumers perception and the decision taken by people working on the food chains.

In this framework, the importance of the interaction between the quality of the decision taken by people working on the food chain and the quality of food is so important that a unique tool named the Techno Managerial approach was developed at FQD to address the issue. In the Master of Science in Food Quality Management a new generation of food scientists are trained at evaluating how the interaction between human decisions and food behavior will determine the final quality of the food products. I purposely will not go into further details of this topic because I hope that in a few years you will have the opportunity to attend the inaugural lecture of a personal professor in Food Quality Management.

As all the rings of this chain are connected, it is possible to look at the interactions between the factors starting from different points: for example, once a processing technology is established, we can select the appropriate raw materials and the consumers will have a different perception of the product. In the same way, looking at the chain from the the perspective of target consumers, the different aspects of food development as well as the importance given to the physiological effects, can be modified to improve the product appealing.

Due to its nature the food chain approach cannot be limited to a specific food chain: in Figure 2 the case of broccoli chain is shown as a lot of work has been done at FQD in the past; similarly I worked intensively in Naples on coffee and cereal chains and also FQD dairy science people adopted the food chain concept for their investigations on the relationship between milk composition, its biological properties and the quality of dairy products.

In this framework, it is clear that the food design approach can offer solutions to many problems requiring no linear thinking and an holistic, multidisciplinary aptitude. Reaching the proper balance between the broadness of the chain approach and the depth of the scientific research necessary in the Academic environment, is not a trivial issue and actually to produce top quality scientific publications pursuing interdisciplinary science is a big challenge. To manage this complexity, appropriate modeling tools are necessary: in the last years, under the lead of Prof Van Boekel, kinetic modeling, regarding formation and degradation of key compounds during processing, have been developed. Following this line, the possibilities offered by

System Dynamics and Agent-based modeling applied to food design and food quality will be explored in the future.

Now I would like to illustrate some potentiality of the chain approach in the design of healthy food products, the so called functional foods. About ten years ago the idea that this could have been a kind of promised land for food industries was very common. This feeling was based on the increased consumers' awareness about the relationship between food and health; on the possibility offered by the new EU regulation about the health claim labelings of food and on the increasing need of healthy foods determined by the population aging in Western countries.

Unfortunately, the development of the field was not as expected. The promised land turned to be a very dangerous land and functional foods developers collected more frustration than successes. As a matter of fact, consumers were not so ready to pay more for products whose beneficial effects they do not really understand ; the European Food Safety Agency had a very restrictive policy in the health claim release and finally the lack of a common language inside the companies between marketing and R&D people led to trivial mistakes in the functional food market placing. The final result was that about 90% of the healthy products released on the market were withdrawn in few weeks with significant losses of money and the trust of company management in this opportunity severely declined.

Despite this dark scenario, the main reasons to design healthy foods which can prevent the development of not communicable diseases and can contribute to the well-functioning of our body are still existing. So the goal to reduce the failure rate in healthy foods development is always a priority. This can be achieved by setting up a sound process combining the obtainment of solid scientific evidence with the capacity to provide proper answers to real consumers' needs. Exactly on this point FQD can give a significant contribution applying the food chain approach. A useful starting point in healthy food design is to identify the physiological target: a list of targets of possible interests is reported in Table 1 together with the main category of potential consumers.

Physiological target	Consumer target
Mental performance	Students, business people, elderly
Cardiovascular disease	Elderly
Weight management	All people interested in controlling their weight
Beauty foods (skin, hair care)	Adolescents and women
Antioxidants and anti-aging	Sports people
Bone and joint health (osteoporosis and arthritis)	Elderly
Intolerance and allergy	Affected by specific pathologies
Functioning of gastro intestinal tract	All people interested in healthy diet and nutrition

The experience of the last years showed that a few successful products were really able to shift the concept of functionality for some of the above mentioned targets: for example to improve mental performance there is a new product containing a mixture of caffeine and taurine which is now able to contend coffee its traditional role of wake-up beverage. A new market has been opened by food targeted at intolerances and allergic people. Their consumption far exceeds the number of people who really have pathologies and eating "foods free from something" becomes attractive to many consumers. On the other hand, products such as those targeted at the benefit of the skin, the so called nutricosmetics, despite the considerable investments made by major multinational companies, failed to reach massive consumption and remained a very niche market, thus far.

The healthy foods on which we will focus our activity in the next years will be those targeting the gut health which is by far the largest sector for healthy food products. One of the reason is that consumers immediately correlate what they eat with the effects on gastrointestinal functions. A number of recent scientific discoveries about the functioning of human gastro intestinal system, suggested several possible targets for healthy foods design. They can be aimed at triggering different bio-chemical pathways and physiological functions. In Figure 3 a list of the possible targets and the underpinning mechanisms are summarized.

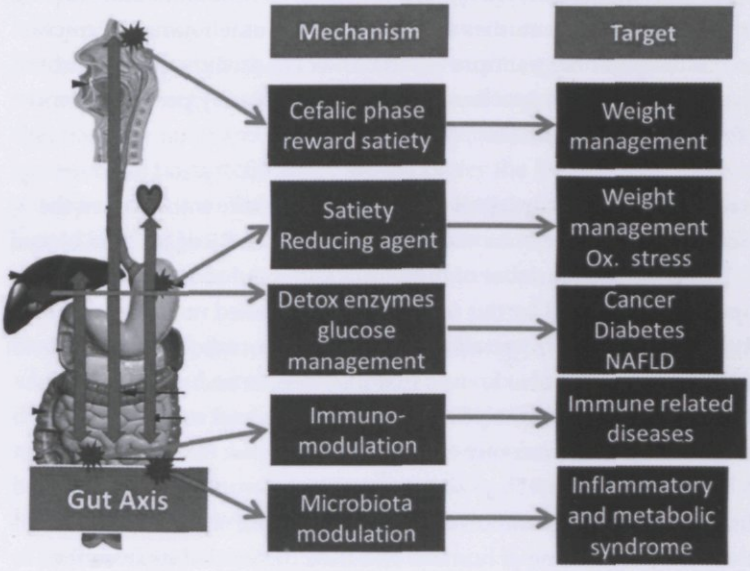

Figure 3. Possible targets for designing healthy foods aimed at improving gastro intestinal tract functionality. Gut-liver; gut-brain and gut-hearth axis highlight the relationship between microbiota modulation and the functionality of other body compartments.

Satiating foods aimed at weight management can be developed inducing the secretion of gastro intestinal peptides and/or by modulating the reward system. Foods with anti-oxidant functions can be effective particularly in the stomach where the formation of nitrogen radicals is particularly aggressive. Also we can design foods which release, at appropriate time and concentration, compounds able to stimulate the liver detoxification system and effective for cancer prevention. At the same time this foods can target also fatty liver disease. The interaction of some food components, mainly peptides and oligosaccharides, with the intestinal immune system (GALT) has been already demonstrated and finally the possibility of foods to modulate human microbiota is probably the most interesting and diffused target with a number of products already available. However, also regarding gut microbiota modulation, there are many signals showing that it is time to go for a new generation of healthy foods. In this respect the future investigations at FQD will be guided by the concept of "gut axis": the strong relationship between what happens inside the gut lumen and the consequences for brain, cardiovascular system and liver can be the cornerstone to pursue the concept of healthiness through the gut.

Some years ago, on the basis of different scientific evidence, the importance of the antioxidant dietary fibre has been postulated. According to this view, anti-oxidant not digestible material (such as the cereal dietary fibre) can play a fundamental role in the modulation of gut functionality, keeping a reducing environment and shaping the profile of our microbiota. Some studies showing how the amelioration of microbiota equilibrium has the potential to improve biomarkers of cardiovascular (gut-heart axis) and liver (gut-liver axis) functionality have been already performed and will be the basis for future investigations.

To introduce the relevance of this concept it is appropriate to take into account the co-evolution which occurred between humans and the community of bacteria hosted in our lower gut. This enormous number of individuals adapted to survive metabolizing the components discarded by our organism, the so called not bioavailable food material. The bacteria ability to metabolize not digestible carbohydrate has been widely studied, however now it is also known that they release and metabolize the fibre associated components such as the phenolic compounds and some of their biotransformation pathways were recently elucidated.

In the effort of designing a new generation of food for gut health it is worth to consider the evolutionary timeframe of humans and their dietary habits from the appearance on earth six million years ago as it is summarized in Figure 4.

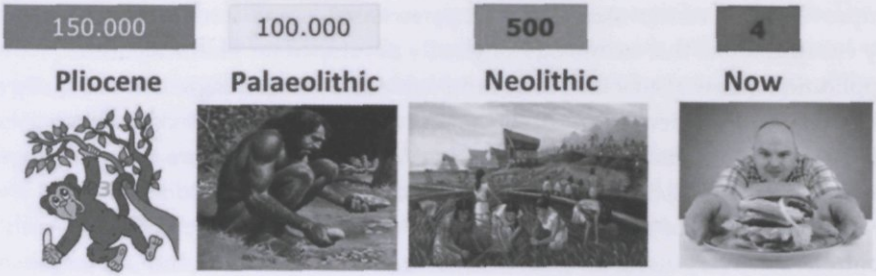

Figure 4. Evolution of humans' dietary habits. Microbiota co-evolved with humans and, as it happens for our body, the evolutionary mechanisms were not fast enough to cope with the abrupt switches of the dietary habits. The first one was at the Neolithic time, with the introduction of starch and livestock products; and the second one was in the second part of the previous century with the large intake of energy dense foods.

It was calculated that for the first 150.000 generations we were like monkeys conducing an arboreal life continuously eating fruits and vegetables. Later on, in the Paleolithic era down from the trees for 100.000 generations the hunter-gatherer men wandered the savannah eating seeds, roots, berries, raw meat and bone marrow. During this long period the microbial consortium in our gut accustomed to receive an enormous amount of vegetable fibre, plenty of antioxidant compounds. Indeed, it was only 500 generations ago that humans started to massively consume starchy foods and animal products and it is only since 4 generations that we switched towards an energy dense food diet plenty of fats and refined sugars. It is obvious that both our body and our microbiota cannot adapt properly to this sudden switch: our bacterial hosts definitively would prefer the feeding they received at the hunter gatherer man-time. Therefore, a simple solution to properly feed our microbiota would be going back to the Paleolithic diet and in fact, there is someone who suggests this solution to solve the obesity related problems.

Unfortunately, it is not possible to feed the world population with seeds, roots and raw food and actually most people are not ready to give up soft, crunchy and delicious modern food products . Nevertheless, the need to properly feed our microbiota is a real nutritional priority and, as food scientists, our objective should be to provide the knowledge and the tools to design affordable and delicious foods for the benefit of the gut microbiota. I would like to provide you some examples of how this can be realized:

1. By formulation: this is the simplest and most direct strategy. Using an arabinoxylan-enriched fractions of wheat bran combined with inulin, it was possible to design a pasta product keeping the original sensory feature of the

traditional one, ameliorating many gut functions and providing significant improvement to cardiovascular related parameters.

2. By encapsulation: this technology originally developed for pharmaceutical application is now available at costs compatible also for food ingredients. Usually the bioactive ingredients constituted the core which can be included in a coating made of proteins, lipids or polysaccharides. As illustrated in Figure 5 this coating can be opened using the acidic pH of the stomach, the proteolytic activity in the duodenum or the action of bacterial enzyme in the lower gut. In this way a controlled delivery along the gastro intestinal tract is achievable and it is therefore possible to bring useful compounds to the microbiota.

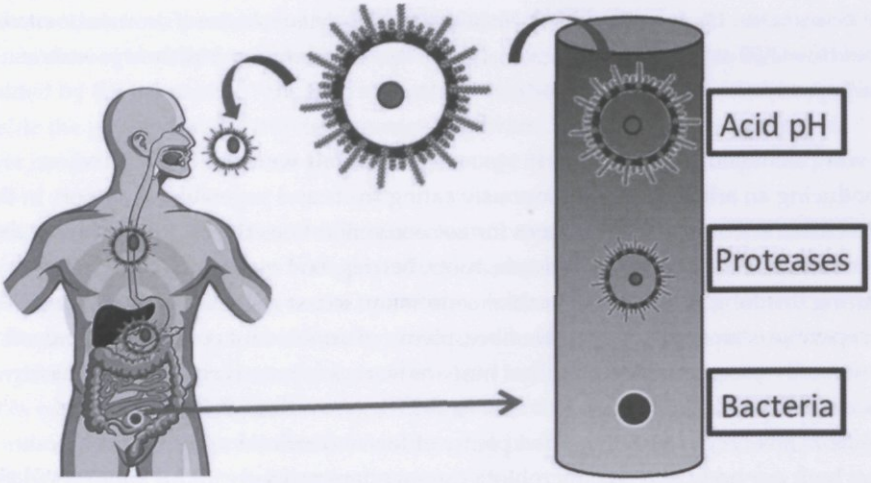

Figure 5. Encapsulated ingredients can be used to design food targeted at the different functionalities along the gastro intestinal tract. The coating could be dissolved in one of the compartments releasing the bioactive core.

3. By processing: it can be designed to maximize the formation of desired compounds minimizing the presence of not desired ones. Melanoidins are a component formed in a lot of staple food such as coffee and bread through the non-enzymatic browning reaction (the Maillard Reaction). Melanoidins are not digestible antioxidant polymers that behave like a dietary fibre and several positive effects have been attributed to them. Coffee roasting provides a nice example of how the amount of this component in the final beverage linearly is related to the processing. Light roasting "Dutch style" provide half amount of the melanoidins which can be obtained using a dark roasting "Italian style". So we can easily imagine that it is possible to design a coffee for the benefit of microbiota.

In the future years at FQD our research will be focused at designing appropriate food matrices to target the different functions present in the gastrointestinal tract. The proof of concept will be realized using a pasta-like matrix with different amount and types of proteins, starch and polysaccharides to modulate place and kinetics of the release of phytochemicals and/or other bioactive ingredients. A good understanding and an appropriate modeling of the interactions between food components in the gut will be our contribution in the collaboration between food and nutrition sciences. Primary physiological targets will be satiety, anti-inflammation, glucose management, detoxification.

I took the design of healthy foods as the main case of how the food chain approach can be used to generate innovations and new knowledge. Now, in the second part of my lecture, I wish to give you two flash ideas of other possible problems requiring multidisciplinary thinking and that can be tackled using the food chain approach. In particular, I will deal with the issue of new sustainable ingredients and with the opportunities coming from the use of insects as potential source of food and feed. Finally, I will discuss how the interaction between food products and human behavior is fundamental to find appropriate solutions to provide food for the future metropolis which is one of the themes that are at the very center of the recent AMS – Amsterdam Metropolitan Solution – initiative where Wageningen University is playing a pivotal role.

Insects represent an edible material of great potential interest for food scientists. They are able to convert in a very efficient way waste biomasses into proteins, lipids and polysaccharides. Despite the cultural barriers related to their consumption, scientists and policy makers concurred in considering insects as one of the best opportunities to cope with the need of feeding humanity in the future. When the food chain approach was applied to the insects case, see Figure 6, it was immediately clear that also in this case there were the same challenges as in traditional food chains.

Looking at the selection of the raw materials, there are thousands of insect species, different stages (eggs, larvae, adults) and different part of the insect body (muscle, hemolymph, digestive tube and exoskeleton) exactly as it happens for vegetables and animals. According to their characteristics, insects can be processed and formulated to obtain foods, feeds or food ingredients and the technical challenges to be solved are pretty similar to those encountered with other raw materials, for istance the rapid enzymatic browning due to the huge polyphenol oxidase (PPO) activities. Moving on across the chain, the nutritional consequences of insect intake need to be investigated also addressing the safety issues.

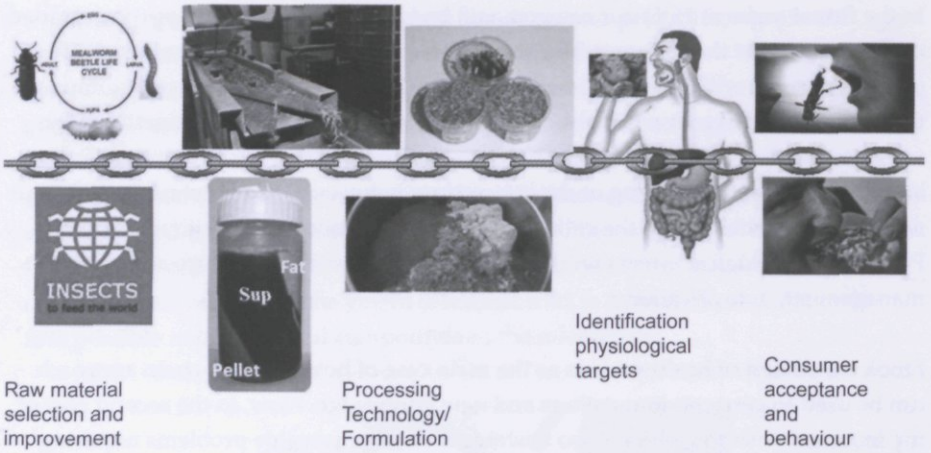

Figure 6. The chain approach applied to the case of insect made clear how the new food source had the same challenges of the conventional ones.

Finally, it is not necessary to explain here how the consumers' behavior will play a tremendous role. In this respect, it would be very important to implement communication campaigns able to raise the awareness of consumers about the unique ability of insects to close the food chain into a circle. It will be of utmost importance to explain how, because of their ability to grow on the waste of the other food chains, insects can be a precious tool of the circular, sustainable economy.

The issue of designing food contributing to sustainable solutions for the future of humanity, must face the evidence that the expected growth of world population is not generalized, but will be concentrated in big cities often with more than ten million inhabitants. The fast migration into these cities, particularly in developing countries, is causing malnutrition linked to the loss of traditional food and consolidated dietary habits. Is it possible to design food products that can counteract this phenomenon and at the same time sustain the economy of local communities? With this challenge in mind at FQD we are performing several projects in Benin, Zimbabwe, Uganda and Zambia applying the chain approach with the aim to find solution allowing traditional local production to get into the modern distribution chain. The goal here is to re-design local production systems to deliver into the metropolis safe and nutritious traditional products. Mabisi, a Zambian fermented dairy product can represent a good case study. A basic microbiological characterization, showing the existence in this product of peculiar microbial consortia, allowed to set the scientific basis for its systematic improvement. In the future, working with local producers and food chain players, we aim at re-introducing a safe, delicious traditional Mabisi in the diet of the citizens of Lusaka, the Zambian metropolis.

On a global scale the proper management of food production chains inside big cities is one of the aims of the AMS – Amsterdam Metropolitan Solution – initiative. Multidisciplinary projects and training programs will be clustered to provide solutions to the urban challenges of the future metropolis. Among the other needs, providing high quality food in a sustainable way required the action of food scientists able to talk a common language with engineers, urban architects, energy and logistic specialists and, in this respect, the expertise and tools developed at FQD in the last years can be very useful.

This passage leads me to the final part of my lecture, where I wish to illustrate my vision about the unique positioning of the FQD group within Wageningen UR. I want to say that I'm very honored to have the opportunity to lead the group founded by Wim Jongen and consolidated by my predecessor Tiny Van Boekel. The peculiar identity of FQD nicely fits into the efficient organization of the Food Science cluster at Wageningen University as depicted in Figure 7. This is a solid temple where the strength of the four pillar sciences constituting the core of each food science program are rounded off and endorsed by the presence of FQD. The scientific and educational activities of the group have solid roots in the food cluster and at the same time they favored the collaboration with different disciplines. Many actual examples, such as those I have just illustrated, showed how FQD activities and the food chain approach can improve the quality of collaborative researches with social science, nutrition, animal science and in particular with the applied researches performed at the Food and Biobased Research institutes.

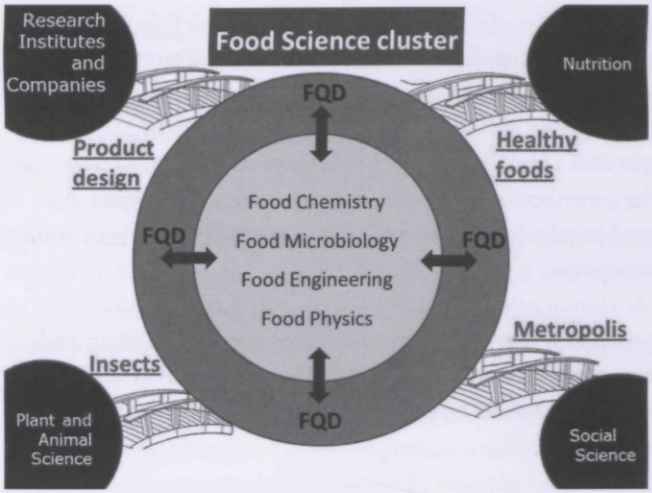

Figure 7. Positioning of the Food Quality & Design groups within the Food Science cluster and in respect to other groups at Wageningen UR.

In the next future our multidisciplinary studies will focus on the relationship between food design and consumer's health. At the same time we will be at the forefront exploring new food chains and redesign traditional ones to accommodate them with the needs of the XXI century. Being part of a leading world University in the Agro-food sector we feel the responsibility to play a pivotal role in the education of a new generation of open minded food scientists having in their mind the keywords of this lecture as visualized in Figure 8. We look forward to spread, particularly through our Master and PhD students, the food chain approach in industrial product development.

Figure 8. Word cloud obtained with the text of this inaugural lecture.

With these statement I would like to conclude the scientific part of my speech and move to the personal part.

There is a number of people that I feel I have to acknowledge at the end of this speech; in fact there was the contribution of many people: families, colleagues and friends, if Vincenzo managed to take his first class ticket to reach the temple of Food Science at Wageningen University.

At the same time I have to thank all those who are making possible a pleasant, and apparently successful, permanence in this new, amazing Dutch environment. Special thanks to all the Italians at Wageningen starting from Edoardo and Teresa who helped me in the first weeks.

Actually when I saw some months ago the scheme prepared by Prof. H. Voraghen (see Figure 9) reporting all the names of the Professors who worked in this Department I suddenly perceived all the weight of the huge tradition of Wageningen food science. I felt like a fresh Atlas with all the food world on his shoulder.

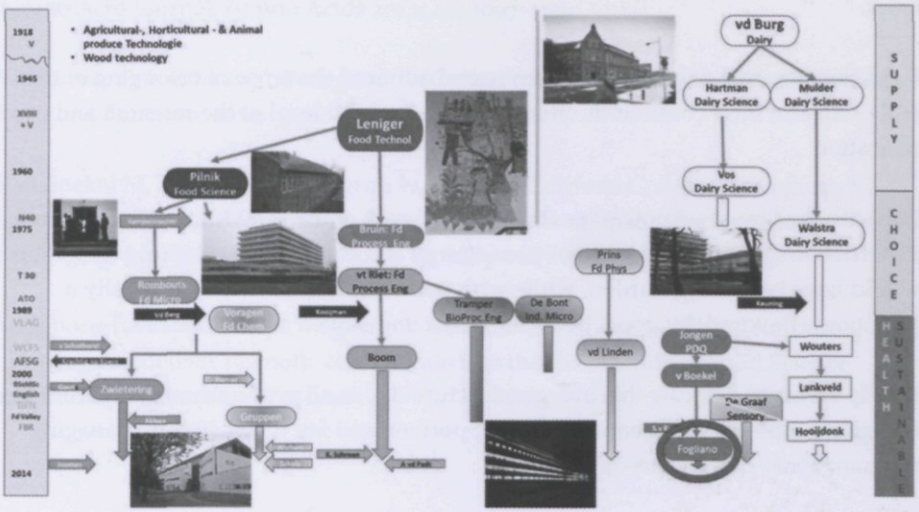

Figure 9. Professors serving at Wageningen University in the food science domain area (illustration kindly provided by Prof H. Voragen).

Likely enough, I very soon experienced the advantages to work within the excellent Wageningen UR organization. Thanks to the other Food chairs, to Raoul Bino and Rob van Meegen and in particular to the wise and detailed suggestions of my "coach" Marcel Zwietering I managed to cope with the issues related to the chair duties.

On the other hand you have to realize that as any good Italian I have been training myself on Food Quality since my early childhood and twenty years at the Department of Food Science at the University of Naples provided me skills, knowledge and experience to manage the complexity, really all kind of complex situations.

I cannot forget here to mention my first mentor at the University Prof. Giacomino Randazzo who thought me the importance to openly talk to people: I learned from him that a scientist should listen and be humble, even the most improbable person could provide you some interesting ideas. I have to admit that this prediction turned to be particularly true in the food world.

A special thank you goes now to my team in Naples, particularly to Paola, Alberto and Luigi: you know I'm very proud of what we did in the past and I'm sure there will be other successful stories made in LABS.

I wish to thank the enthusiasm of Wageningen students and the energy of the FQD PhDs they represented the perfect stimulus renewing my energy for the everyday work.

From my very first day here in Wageningen I admired the sense of belonging of the FQD staff and their continuous efforts to keep the high level of the research and education.

In particular I must acknowledge the precious work of the FQD Mini-MT committee: Pieternel, Anita and Ruud without your energy and competences chairing the group would have been a big burden, while with your continuous help it is usually a pleasure... flavored by good beers, nice chat and skilled squash lessons.

Finally I wish to dedicate this Inaugural lecture day to all my family starting from the two grand mothers who continuously support me and my wife Laura in managing the complexity of the everyday life!

Thanks to my children Claudia, Antonio and Virginia: today you have the opportunity to see the other side of the coin of a father who usually answers you with some delay because his hands are always on a laptop!

Last but not least the biggest thanks of today go to Laura: I wish you know that if I'm here now, if I have become professor in Wageningen it is because you have always been at my side all days of the last 20 years.

Ik heb gezegd; 'e chest'è!

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Professor Vincenzo Fogliano

'Effective food design requires deep knowledge of the food chain rings from the selection of raw material, through formulation and ingredients, up to consumer behaviour and potential health effects. The food chain approach allowed to increase the quality of product development at industries, creating opportunities for innovative basic and applied researches. Its relevance for designing healthy foods for different targets will be illustrated

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