



Science & Technology

FORESIGHT

from society to research

Report

“Diversified Adaptable Food”

6-8 May, 2015 - Rome

WG FOOD

Converging technologies for Sustainable and Healthy Food

REPORT

1st F2F Workshop: Diversified Adaptable Food

6th-8th May, 2015

La Borghesiana – Rome, Italy

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Background documents to the workshop, as well as all position papers written by the presenters, can be found in the booklet at *foresight.cnr.it*. This report has been validated by the scientific committee.



REPORT

by *Cecilia Bartolucci*
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1. PREFACE

The work of the Science and Technology Foresight Group originates from the **needs of the society**, considered to be the most important drivers for responsible development and innovation. During the “face to face” workshop, held in Rome on May 9-11, 2015, this approach found wide support within the 50 international experts gathered around the table*. During the discussions it was stressed that technologies should not be the starting point of our foresight exercise rather, whenever addressing technological advances, the key question should be how they can **benefit a broad community**, and which societal needs can they address. Creating **knowledge** is another concept, emphasized in our foresight approach, which found great resonance among all participants. It is through the acquisition and sharing of knowledge that we can push the boundaries of research and innovation, creating incentive and motivation to take action.

* Booklet to be downloaded at: foresight.cnr.it

Challenges

Considering the projected increase in the world’s population in the next decades, some of the greatest challenges to mankind will be to sustainably and equitably provide better living conditions, deliver vital goods and services, and support human health and well-being. In particular, there is a need to **provide global food security**.

In this regard one of the main results of the workshop was to conclude that the **quality** and not the quantity of the food should be addressed. The experts pointed out that there is enough food, and in particular there are enough calories to provide food even for a fast growing population, (we produce enough calories globally to satisfy 12 billion people, more than sufficient therefore to even meet the needs of the projected population of 9 billion in 2050) but the **nutritional value** of such food is often insufficient to ensure a healthy diet. However, even the intrinsic quality of the food is not enough to ensure a nutritious diet since **diversification** of the nutrient content is essential too. Better matching of the nutrients to specific needs is required, eventually allowing for the production of **individually optimized food**.

In this context, a permanent cultural change in behavior is crucial. This takes time, perhaps generations, and has to be supported by appropriate actions and tools. The need to provide **knowledge** was seen as imperative. Through education, individuals are empowered to make choices and take responsibility for the consequences. Building that knowledge is not only based on the



acquisition of **scientifically based data**, but requires that this knowledge is shared with the community at large through appropriate **communication** and **education**. A cultural change should not only be expected in the consumer, but also in all other stake holders, including scientific communities, policy makers, and industries. Communication among different sectors as well as an **interdisciplinary approach** will be necessary if we are striving to integrate innovative technologies into social change.

Two more aspects hampering food security and sustainability were pointed out, namely an inadequate **food distribution** and **waste**. Both greatly affect the quantitative as well as the qualitative aspect of food production. At present, the amount of food we produce is sufficient to feed all, if we were able to make it **accessible** to all societies, in particular to the poor ones and to those present in underdeveloped countries. A better distribution system should allow accessibility to not just any food, but to healthy food, that means to nutritious and diversified food. Furthermore, we should produce only the amount we need, using resources in a more sustainable way. Waste is generally associated with quantity and not quality, however reducing waste is an essential component in emphasizing nutritious food. There is waste at every stage of the food chain, which means that there is improvement potential at every stage, adding value to waste by enabling its usage. Through the new acquisition of knowledge, the application of innovative technologies, and especially through a better-developed system approach, we should eventually be able to reach **zero waste** production.

2. CONSENSUS

- **Nutritional quality, rather than quantity, is the highest priority for providing an adaptable and more tailored food supply while fully recognizing specific needs of diverse societies.**

The scientific world is becoming increasingly aware of the link existing between health and diet and the importance of a nutritious, diversified diet. Non-communicable diseases (NCDs) affect millions of people each year, one of the main risk-factors being an unhealthy diet. Making staple food more nutritious could provide a tangible preventive benefit. In the future, however, the production of a **food supply tailored to specific needs** could have a disruptive impact in terms of health and general well-being. *Knowledge needs to be acquired, which will allow a better understanding of the relations between health and nutrition, based on which existing or new technologies will need to be developed and integrated.*

In particular, since dietary requirements are varied, in order to have an adequate nutrition, we will need to be able to monitor changes in metabolism, evaluate nutrient needs in a dynamic way which takes into consideration the complexity of the whole system. The tools used to achieve that should eventually reach the consumer, and deliver the necessary information to allow knowledge based decisions. Acquisition of knowledge regarding our **genome, microbiome and phenotype** can lead to preventive, personalized nutrition in combination with preventive and personalized medicine. *Development and integration of genomic, metabolomic, epigenetic, nutrigenomic, quantitative biology, and big data will be necessary. Realization of new technologies which will lead action on those data will be essential as well.*

The stress lies on **prevention** and *it is mandatory that scientific based knowledge and new communication strategies support a change in attitude* that also recognizes a scale of action. Acknowledging the longer life expectancy, it is important to realize that investing in a healthy nutrition today, will result in a better life quality tomorrow.



Within the food chain, the protection or the introduction of nutrients should start as early as possible. Taking the whole system into consideration, all possible points of improvement should be identified: this adds value and supports the consideration of byproducts as additional raw materials, reducing waste. *Technologies* that until now have been used mainly to enhance productivity in terms of quantity, *should be used and developed to enhance quality*. Starting from the quality of soil and crops through the use e.g. of nanofertilizer and nanopesticides, or nutrients delivery systems, to fortification through micro- and nanoencapsulation, or use of processing technologies which will protect nutrients and enhance their bioavailability. All these applications could add value to the products. Validation procedures as well as safety tests will need to be introduced at all steps of the chain, in particular when new technologies or new materials will be used. This should also consider a reverse approach “from fork to farm”, starting with the analysis of food absorption, and back to the structure dynamics, checking efficiency and safety of the proposed solution.

Technological innovation, in particular of converging technologies, has the potential of addressing all quality issues (e.g. nutrients bioavailability and protection, shelf life, environmental impact, etc.) *providing adaptable solutions*, which will support the production of an “**on demand**” food supply. In fact, to support sustainability we will need to produce only the food required both in terms of amount as well as nutrients. “On demand” has a dual meaning, qualitative and quantitative: we will produce only the amount of food necessary for a healthy life and well being. At the same time we will produce food tailored to the specific needs. This might even involve the preparation of food from modules or single ingredients that can be assembled, allowing **personalized food formulations**.

- **Diversity in diet supports the capability of providing a nutritious sustainable food supply in all societies.**

Nutritional value in food is core to a healthy diet and hence to a healthier life but it would not be sufficient without food diversity. This spans from agrobiodiversity to a diverse diet. At the moment we are using only very few plant and livestock species (75 percent of the world’s food is generated from only 12 plants and 5 animal species, and only 3 crops – rice, maize and wheat – contribute nearly 60 percent of calories and proteins obtained by humans from plants). We know however that diversity can make farming systems more resilient and more sustainable, contributing to pest and disease management, soil health and fertility, and efficient use of resources and the environment. It can also sustain economies in fragile areas and create income opportunities, reducing dependency on external inputs. In view of the unknown extent of the impacts of climate change on the environment and agriculture, *it is crucial to develop a food system that promotes agrobiodiversity*.

A more diversified food production entails a **decentralized production**, able to use local resources and more easily adaptable to specific requirements as well as more adaptable to environmental, health related, economic, cultural and social challenges. This should allow for greater availability and affordability of different nutrient sources, supporting both the concept of a **food supply tailored to specific needs**, as well as an **on demand** production.

The impact on nutrition and food security would be relevant if, thorough the application of newly developed, or through the increment of already existing technologies, we could provide new sources of nutrients, in particular of proteins. Despite the need for land, growing legumes offers a fairly sustainable alternative, and it provides a diversification from animal proteins. However, other sources, such as yeast and microalgae for single cell cultures, need to be exploited. This requires the development of new technologies, in particular to upgrade the production. New processing and formulation technologies are also necessary to allow the utilization of the greatly variable source of



proteins and fats provided by insects. Different formulations could facilitate the use of insects also in societies, which are still reluctant to introduce them in their diets.

We need to create diversity in the food system to provide adaptability to climate change and to public health challenges.

- **Significant changes in the commercial supply chain in all societies and integration of existing and converging technologies are needed to responsibly ensure a nutritious food supply.**

We need to develop a new cost effective approach to food production. This can be accomplished through the application of emerging technologies enabling a **distributed and networked food production system**.

In recent decades, and in many countries, food production has evolved into an ever more centralized model. While this has generated notable advances in productivity, enabling us to produce enough calories globally, it has also failed to adequately distribute the food produced or to meet the nutritional needs of our societies.

We need to move toward a more robust and responsive system, better able to guarantee an effective distribution of the food supply according to local needs. This new distributed model should be targeted to *produce when and how much is needed by the society*. Distributed versus centralized: the idea is that of an **intelligent network of food distribution** in order to manage it efficiently, where the nodes of the network represent the sites of food production and are as close as possible to the consumer. Where the means of production are optimized and information gathering and sharing reduce waste and increase value added. The application of emerging **digital information and communications technology** will be vital in order to gather and act on information - such as information about the behaviours of suppliers and consumers but also current and future weather and market conditions and anything that could affect the value chain. **Enhanced traceability** through the use of new sensors and **new sensor** networks, but also the **embedded traceability**, through the use of new nano and biotech approaches, will further improve consumer confidence and help reduce waste. New **transformational technologies** will enable the optimization of raw materials and recycling of certain elements of the production process, and alternative approaches to **food contact materials** and storage techniques, coupled with technologies such as **3D printing**, will enable localized production of more tailored foods from the raw materials produced by the system.

We need to develop new technologies that make better quality food in a distributed system and we need to improve efficiency in the market and share information to coordinate actions. This system could enable the optimal use of raw material. If there is a surplus of production, immediately the smart grid would allow its distribution where there is a deficit/need for it. In this way there would be less waste of food and a more efficient use of raw materials because there would be a real time distribution of the surplus.

3. CONCLUSIONS

- **“Diversified Adaptable Food”**

One of the main goals of the workshop was “to define key principles on which a stable, sustainable **Diversified Adaptable Food Supply** can be based and further developed”. We had also



emphasized the need to address the issue both, from the perspective of developed, as well as developing countries.

During the workshop the participants acknowledged that the development of an adaptable supply chain will potentially allow us to meet a variety of very divergent needs and to produce diversified food. Initially the tracks for the developing and the developed countries will be different, but eventually they will meet. Providing nutritious food is also a socio-political challenge. High value food can already be brought to needing societies in emergency situations, but in a long term, work with these communities is necessary to gain acceptance and trust.

Through the adaptation of successful, cheap and easy technologies we need to implement the connection between developing and developed economies, providing access to markets, incrementing diversity and reducing waste. Some solutions and some innovation may come from centralized research efforts, others may be developed in nodes of the distribution network, independently of developed/developing countries, following stressers that are relevant to technological applications.

- **“SmartGrid for Diverse Adaptable Food”**

Applying emerging technology to build resilient nutrition supply networks

Next “Face to Face” Workshop, October/November 2016

In a long term vision, the experts gathered at the workshop recognized the need to develop a new **food system approach**, which supports a more distributed and robust supply chain, considers the environmental impact along the whole production chain and after the use as well, and analyzes and accounts social impacts, benefits and costs. Mandatory is a system that sees the nutritional needs of all societies and the sustainability of the food production as a priority.

Better matching of the nutrients to specific needs is required, eventually allowing for the production of locally optimized supply of nutrition. We must consider the entire nutrition system from what is available to what is needed for individuals, communities, and regions. In order to adapt the surplus of calories to the nutrition needed we will have to plan “upstream” from local needs to the possible source of nutrition. To optimize nutrition supply we already have, we must build supply and use networks that reduce waste of crops, waste of energy and waste of water.

We believe that it is imperative to develop a long-term strategy, while also identifying present points of intervention. Therefore, we propose to start by selecting a few local realities, which we intend to analyze in terms of feasibility regarding the introduction of a distributed network of food production. We are looking for places, in developed as well as developing countries, where presently nutrition is difficult and where convergence of innovative agriculture, better materials to store and process food, better technologies for energy and water utilization, and better data collection and management tools to match production resources, nutrition supply, and need, can shift supply chains and resource utilization to the point where local nutrition efficiency is resilient and sustainable. These case studies will constitute the base for discussion during the “face to face” workshop.

Our vision is that a system for nutrition production and supply similar to the smart grid for energy systems is now possible through joint application of production, processing, packaging, and data management technologies.



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