INTEGRATING GENOMICS TECHNOLOGIES INTO FOOD RESEARCH
THE KEY FACTOR FOR SUCCESS

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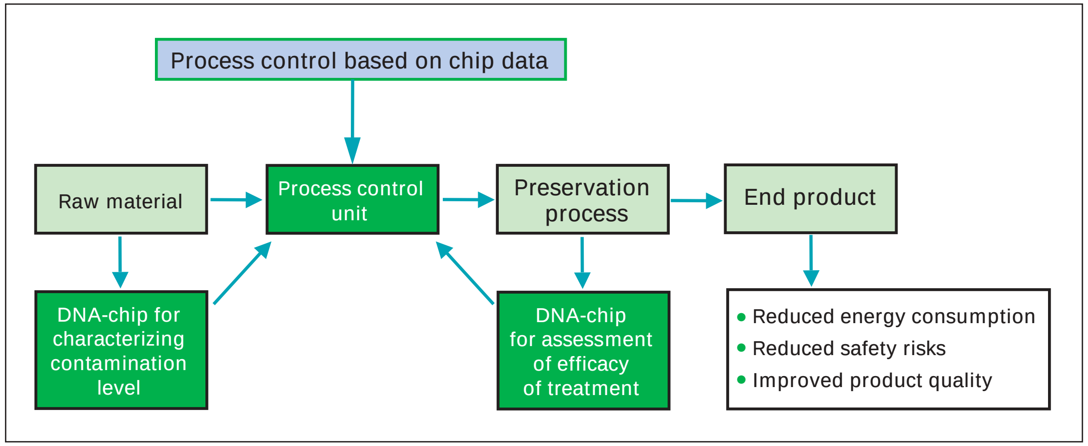
FOOD RESEARCH IN THE NETHERLANDS, A BIRDS-EYE VIEW

The pace of development of new food products and ingredients is increasing at an unprecedented speed and the R&D to efficiently address all needs of the modern consumer regarding taste, health, safety and convenience is becoming increasingly complex. This increasing complexity is creating a need for large multi-disciplinary food research centres. Food multinationals are restructuring their R&D into larger units. Worldwide this is leading to a decrease in the amount of food research; in the Netherlands, however, the reverse is true. Unilever has decided to concentrate European food research in the Vlaardingen laboratory and the Campina dairy company recently clustered R&D on milk and milk products from locations in Belgium, Germany and the Netherlands in the new Campina Innovation centre in Wageningen. A unique example of combining forces for strategic non-competitive fundamental research is the Wageningen Centre for Food Sciences, established by Unilever, DSM, the dairy industry, Avebe and Cosun together with Wageningen University and Research Centre, NIZO Food Research and TNO Nutrition and Food Research. Following the entry of CSM and the medical and health sciences departments of Maastricht University WCFS has been enlarged in recent years to a program of over 125 fte. The program of WCFS focuses on complex issues that cannot be addressed by mono-disciplinary research groups, thereby creating unique expertise contributing to the skill base of all WCFS participants.
Dutch initiatives contribute also significantly to the establishment of international food research consortia, such as the SAFE Consortium - the union of 6 leading institutes in food safety research and consultancy, with INRA - France, ISPA - Italy, IFR – UK, VTT – Finland and two participants of the Netherlands - Wageningen University and Research Centre and TNO Nutrition and Food Research. SAFE is aiming at being a leading provider of authoritative, independent scientific information on food safety. Other signs of a growing international impact of Dutch food research are the numbers of foreign M.Sc. and Ph.D. students in Wageningen and the level of 50% of contract research at TNO Nutrition and Food Research funded from abroad, foreign companies being attracted by the multi-disciplinary skill base of its staff of 700.
A key factor for being successful in the demanding world of food research is the integration of the rapidly expanding genomics toolbox into basic and applied nutrition and food research. In this paper this will be illustrated with examples in the field of microbial genomics whereas the impact of genomics in other fields of food and nutrition research will be discussed more briefly.

Applied microbial genomics for optimized food preservation



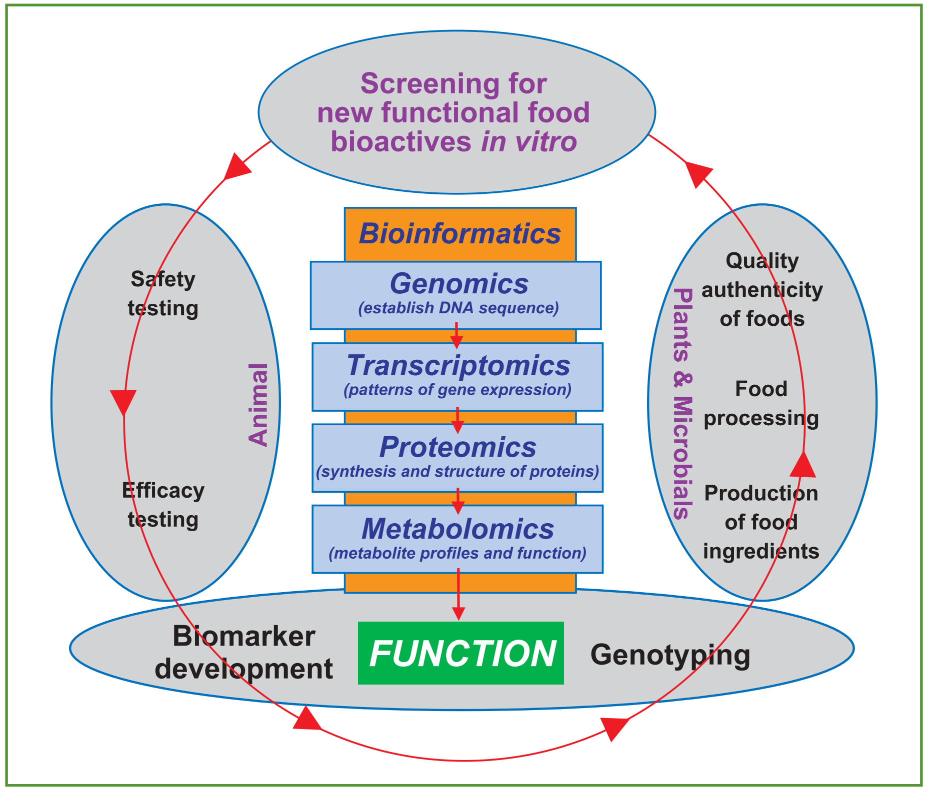
Joint E.E.T. project Unilever - TNO - University of Amsterdam (SILS)

APPLIED MICROBIAL GENOMICS FOR FOOD SAFETY AND QUALITY - HOW DOES THIS WORK?

A cell can be seen as a highly organized collection of biomolecules (DNA, RNA, Proteins, sugars, metabolites and minerals). An alteration in environmental conditions (e.g. a rise in temperature) will initiate a cascade of biological reactions (transcription, protein synthesis, metabolic changes etc.). These reactions are very specific for the environmental alteration. Measurement of all changes in all biomolecules will give the perfect description of that condition (in this case: the temperature). A simple definition of *Genomics* is the measurement of changes in all RNA transcripts (transcriptomics), proteins (proteomics) or metabolites (metabolomics). The study of the interactions between different levels of biomolecules is called *Systems Biology*. Since all these technologies produce large data sets the application of Bioinformatics is indispensable.
To fully exploit the power of these novel technologies a new scientific approach has developed. For the past decades a reductionistic approach has governed most research in the area of life sciences. Disadvantage of this classical approach is that the scientist, prior to the performance of an experiment, decides to focus on only one detail, based on a ‘gut feeling hypothesis’. The novel genomics technologies make use of a holistic unbiased approach in which the whole set of biomolecules is studied under specific experimental conditions. Application of Bioinformatics (e.g. Pattern Recognition) will result in identification of specific biomarkers relevant for the condition under study. If desired detailed studies on selected biomarker molecules can be started at this point.

APPLIED MICROBIAL GENOMICS FOR INNOVATION AND OPTIMIZATION OF FOOD PRESERVATION

Consumer demand for fresh tasting products and for convenience foods – such as ready to (h)eat chilled multi-component products – is increasing rapidly. Therefore, the food industry is highly interested in mild preservation and in novel, non-thermal preservation technologies



such as UHP (Ultra High Pressure), PEF (Pulsed Electric Fields) and HIL (High Intensity Light).
A major problem of classical food microbiology research is that the effect of the applied preservation strategy on spoilage micro-organisms can only be determined after a number of days and with separate determinations for each organism.
This classical (black-box) time consuming approach (colony counting of surviving micro-organisms on plates) is also limited because the response of micro-organism can only be measured indirectly.
In TNO we are applying genomics technologies to open up this black box by directly measuring the total response of the biomolecules of the target spoilage micro-organisms to the applied preservation methods. By making use of this approach, known as applied microbial genomics, we are able to measure all relevant responses in one experiment. To this end we have developed mRNA micro-arrays with thousands of genes of micro-organisms of our food spoilage microorganism database. This will result in a selection of about 50 to 100 mRNA-type biomarkers and a robust DNA chip for applied research enabling us to predict the outcome of a preservation treatment and to define additional preservation steps if necessary. Our experience in food microbiology, knowledge of food spoilage organisms, skills for extraction of microbial DNA and RNA of food product samples and the input of our large data-analysis group appear to be crucial in this type of applied microbial genomics research.
As a result of this work process control can be improved significantly and energy input for preservation processes can be reduced. This can result in improved sensory properties and significant cost savings by decreased energy costs (due to tailor-made process conditions) and decreased product losses.
Application of microbial genomics is not limited to preservation technologies. In principle all processes in which living (micro-) organisms are involved are amenable to the concept described above.
Examples of applications currently being developed at TNO in co-operation with industrial partners are:

- development of a genomics-based quality control system for fermented food
- development of an integrated system for tailor-made process control for processed food
- development of microbial detection systems for the quality control of raw materials
- identification of novel (natural) antimicrobial compounds

GENOMICS TECHNOLOGIES AND FOOD AND NUTRITION RESEARCH – THE IMPORTANCE OF INTEGRATION

An overview of applications of genomic technologies in nutrition and food R&D is given by Van der Werf et al. (1). In addition to the areas described above, these include screening for novel functional food bioactive compounds, safety evaluation of bioactives and other food ingredients, efficacy testing of functional foods, assessment of quality and authenticity of raw materials and food products as well as optimization of fermentation processes for production of food ingredients and food products. Genomics technologies can create new options, contribute to better insights and can reduce considerably the time span of projects. However, without a solid background in food and nutrition sciences their use may contribute not only to wrong conclusions but also to false alarm – for example by misinterpreting Toxicogenomics results in the safety evaluation of food ingredients. Genomics technologies for food and nutrition R&D are starting to deliver not only promises but also results (2). Here, our broad expertise in correctly generating and handling of massive sets of data appears to be a key success factor. This will become even more crucial due to the trend towards using data of Metabolomic studies and the Systems Biology approach.
Metabolomics as such requires the availability of powerful analytical multi-methods for a broad range of metabolites, such as LC-MS, GC-MS, GC*GC-MS (comprehensive gas chromatography-mass spectrometry) and GC-MS/MS. Our large Bioinformatics and Data-analysis group, being active already long before the existence of Metabolomics and Bioinformatics in handling large amounts of analytical data for the food- and the pharmaceutical industry, is the pre-eminent example of the benefits of integrating existing food and nutrition research expertise with genomics technologies – an integration that is the key factor for success in a competitive world.

References

1) *Van der Werf MJ, Schuren FHJ, Bijlsma S, Tas AC, Van Ommen B, 2001. Nutrigenomics: Application of genomics technologies in Nutritional Sciences and Food Technology J Food Sci 66: 772-880*

2) *Van Ommen B, Stierum R. 2002. Nutrigenomics: exploiting systems biology in the nutrition and health area. Current Opinion in Biotechnol 13: 517-521*

GENOMICS TECHNOLOGIES