Food Foresight: Analysis of the development patterns of the Food Industry and markets using TRIZ concepts

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A small project termed Food Foresight was developed under the aegis of the European Union 5th Framework Programme, key action Food, Nutrition and Health, in 2002, and the final report has just been made available.

The work was developed in co-operation between University College Cork, Ireland (Dpt. Process Engineering), Wageningen University, Netherlands, and the WOIS Institute, Germany. The goal was to apply TRIZ concepts, and one of its related off-shoots, WOIS (Contradiction-Oriented Innovation Strategy, which uses TRIZ concepts and methods as part of its overall methodology), to develop a foresight exercise of the food industry and markets. This was a much wider and vague remit than technology forecasting in conventional TRIZ.

In order to achieve this objective, we performed a series of tasks:

- we started with a one-week workshop to train the work group in WOIS, and apply the concepts to the food markets. It was followed by a meeting with EU officials and experts of the food sector to collect inputs to the blueprint provided by WOIS;
- the work team split in two groups for missions to the USA and to Japan to interview experts, analyse case studies, and identify trends. These missions had the dual purpose of exploring TRIZ applications of interest, and analysing development patterns in food markets;
- Two types of analysis were then developed with the inputs gathered:
    - A systematic analysis of what the abstract patterns of evolution imply regarding the development of the food industry, its challenges and opportunities;
    - A focused selection of specific hurdles for the development of this industrial sector resulting from the WOIS work, followed by general ideas of possible solutions arising from the application of the TRIZ inventive principles.

The results were reviewed in a couple of meetings and the final report was produced. The report contains all details and is freely available for downloading in the Systematic Innovation webpage of University College Cork (http://www.ucc.ie/sysinov/ - follow links to Projects and Downloads). it is composed of the following elements:

- Main body of the report. Contains a summary of the work and provides a contextual discussion of predictions based on analysing patterns of development in industrial sectors in general. These lead to a series of proposals for the food industry which are then detailed. There is also a summary overview of the proposals that result from the more focused WOIS analysis of specific hurdles.
- Annex A. Contains a brief overview of TRIZ and WOIS from the perspective of application to foresight, folowed by a more detailed disucssion of the crucial hurdles selected and possible solutions. These address two major issues: (i) legislation and regulatory framework of the food industry; (ii) application of biotechnology to food processes.
- Annex B. Contains just a very brief overview of the inputs provided by the food industry experts fro Europe in the meeting that followed the first workshop.
- Annex C. Contains an account of the mission to the USA, with an overview of inputs provided in each visit/meeting, and a subsequent discussion. Some visits are particularly relevant regarding the development patterns that are emerging in the food sector, while others provide an insight into TRIZ applications.

It must be stressed that the purpose of this exercise is better served by stimulating responses and discussions, it is not intended to finalise the work with a bland and trivial set of proposals. Therefore the contextual discussions and visions may be controversial. They do not reflect personal or balanced opinions; they are the result of applying abstract development patterns. This technique may result in statements that can be challenged, like any prediction or speculation can anyway, but it has the benefit of providing a suitable ground for discussion and development of innovative proposals.

Results from analysing abstract patterns of development

From the identification and analysis of abstract patterns of development applied to food products and markets, we initially describe 4 major areas of development that we foresee as a result of the underpinning changes in society and enabling scientific and technological tools:

- product design engineering of foods - satisfaction of emotions and needs as the primary drive for product development.
- production on demand systems for foods - development of supply networks with multi-assembly production systems, delivering service at point of sale/consumption with tailor-making capacity. A sub-area is the development of streamlined "lean" manufacturing systems for cheap production of bulk commodities and intermediate products.
- the litigation society - implications of the litigation environment to food products.

- molecular nutrition - the underpinning knowledge of what foods should and should not contain for specific individuals at a specific time.

These four areas provide "visions" of future developments that breed proposals for strategic areas of development. One very important enabling factor in all of them is information: it will be by a greater use of information and knowledge processing that most of the changes envisaged will be enabled (no surprise, as TRIZ predicts that systems often evolve minimising resources and effort by making more use of information and knowledge). This then creates three additional areas of development that we need to consider:

- information and knowledge flow - systems that can acquire, search, retrieve and deliver specific knowledge at specific times and places.
- inexpensive sensors - micro- and nano-sensors integrated in higher level systems or stand-alone, with the ability to analyse individuals and/or food products and provide information required to obtain relevant knowledge.
- technical intelligence systems - knowledge management systems of scientific and technical information for acquiring, searching, retrieving and deploying scientific knowledge for problem solving in process and product development.

A final eighth area of development comes from technological developments, specific of the agro-food industry.

Results from the WOIS application

The focused selection of hurdles to be addressed by applying inventive principles to the underlying contradiction (conflict) addressed a selection of problems extracted on the basis of the input from the Brussels meeting, grouped in two main areas:

- Legislation and regulatory framework
- Application and use of bioinnovations

Some of the proposals repeat concepts already identified in the analysis from abstract patterns of development, which is logical. The most controversial results are likely to be:

- Apply the principle "let industry regulate itself" - current legislative approaches tend to micromanage quality and safety with overdetailed requirements of how exactly they need to be assured in each and every company and process.
- Deploy genetic engineering only in applications where there is a direct benefit to the consumer him/herself, giving lower importance and visibility to those that have

indirect benefits to the consumer (if any), such as environmental, quality constancy or productivity oriented.

Summary of conclusions

An overview of the main conclusions is provided in the next tables.

FROM THE IDENTIFICATION OF ABSTRACT PATTERNS OF DEVELOPMENT APPLIED IN THE CONTEXT OF MODERN FOOD MARKETS	
We recommend the implementation of the following proposals...	***that relate to the following patterns of development***
Invest in the development of cognitive-based product design systems. We recommend that a priority research area should be the development of cognitive-based product design engineering systems. These need to integrate sensory science, cognitive science, food (material) science, nutrition science, social sciences, and translate product and manufacturing parameters (design choices) into consumer's emotions and feelings. We suggest interacting with the Japanese food *kansei* initiative to develop food as a *kansei* industry, aiming at generating added value in the design of the product through its ability to satisfy emotions and feelings.	**From performance of the system (the product is more important) to satisfaction of use (the user is more important)** Sociology has described a pyramid of social needs where satisfaction of emotions and expectations becomes more important than primary needs. Modern cognitive science has analysed buying behaviour in various products and identified how market expectations evolved from performance of the system (the product is more important) to satisfaction of use (the user is more important) in other industrial sectors, as society moves up the pyramid of social needs. This is already an emerging trend in the food markets.
Invest in the design and development of production-on-demand systems, with streamlined and flexible supply chains. We recommend that a priority research area should be the development of production on demand concepts, with streamlined and flexible supply chains. We need to integrate supply chain management, production systems engineering, product design engineering systems and information and knowledge processing systems. We suggest exploring existing systems in the electronics and semi-conductor industries as benchmarks to be further elaborated with the specificities of foods and their conditions of use. We envisage	**from production-oriented (the customer buys what we produce) to contract-oriented (the customer tells us what to produce).** In production-on-demand the industry offers tailor-making capacity to the user while minimising surplus inventory and waste in the supply chain. The customer is empowered to request what he/she wants and personalise the product – this enables an important target in the pyramid of social needs: identity and personal achievement. *It is noted that this is unlikely to become the reality of the entire industry. Production-oriented systems will continue to be required, the market is very diverse. However, those systems will also need optimum supply chains, as for them cost minimisation is the most important target. Product development and*

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battling out with the food service sector for the added value of service, convenience and empowerment.	*them cost minimisation is the most important target. Product development and innovation are likely to be secondary objectives in this domain.*
develop procedures and systems for obtaining and disseminating information regarding the use of new products and bioactive ingredients that will protect the industry against lawsuits. We suggest that a priority research area should be the fulfilment of knowledge needs for new products and abused ingestion of food products to be covered by reasonable efforts to protect the consumer, in view of potential lawsuits, should problems later emerge. A particularly useful target would be the development of a cost-effective standardised procedure of investigating unusual side effects and abuse ingestion effects. Another crucial aspect is the delivery means of knowledge and information to consumers.	**trend towards increased requirements for information and knowledge use as systems evolve (and growth of a litigation society)** The food and drink industries will be increasingly concerned with litigation from individuals who suffer the results of abused ingestion of particular ingredients or food components and claim not to have been warned of limits and effect of excess ingestion, and other reasons for lawsuits. In order to protect against these costs, companies will be advised to provide various type of information, specially regarding new ingredients, which can lead to information overload by the consumer.
invest in the understanding of the human metabolism at molecular level. We recommend to search for the information on the relationship between food products and people at the molecular level, rather than sociological studies searching for correlations between eating patterns and specific diseases or conditions. We need to understand how the human metabolism is influenced by food constituents (presence and absence) as a function of environmental and individual factors	**from basic understanding, which is general, to more detailed and deeper understanding, which must be tailored.** *This is accompanied by the shift in information being generated at macro-level ("bird's eye" views of general patterns for a basic and generalised understanding) to micro-level (focused and specific pieces of information which are integrated for the tailored result).* Nutrition and dietary advice based on macro-patterns of health and food intake will become increasingly mixed, confusing and

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(including genomic predisposition, mood, age, specific requirements, etc.) at the molecular level. This will generate specific, atomised, elements of information, which can be integrated to analyse needs and requirements of individuals at any specific time.	untrustworthy. We need to move from macro to micro level.
invest in the development of information and knowledge processing systems to relate products with consumers throughout the supply chain We recommend that a priority research area be devoted to the development of information and knowledge processing and delivery systems from consumers (towards product design and the supply chain), and to consumers (from product characteristics, nutritional and medical data). These efforts underpin many of the developments discussed earlier, and will need to meet various needs such as (i) knowledge management systems of nutritional data; (ii) knowledge management systems of interactions between food constituents and human metabolism; (iii) information and knowledge search and retrieval systems to deliver tailored information to consumers on demand, accounting for the particular requirements of the individual; (iv) information and knowledge flow from consumers (from product design) all the way up the supply chain (to product delivery).	**trend for increased use of information and knowledge** Systems evolve from one stage to the next, improving performance and effectiveness (usually while minimising resources and effort), by making increased use of information and knowledge.

FROM THE IDENTIFICATION OF ABSTRACT PATTERNS OF DEVELOPMENT APPLIED IN THE CONTEXT OF MODERN FOOD MARKETS	
We recommend the implementation of the following proposals...	***that relate to the following patterns of development***
invest in the development of micro and nano sensors for two important tasks: (i) analyse metabolic conditions in individuals and (ii) verify safety hazards in food products We recommend that a priority research area should be the development of inexpensive micro and nano sensors that can effectively perform basic analytical measurements of relevance to individuals or to food products, providing information for dietary or safety evaluation.	**requirements for information capture** (of other areas previously discussed)**; and trend of systems towards incorporation in systems at a higher level** (safety assurance system incorporated in products rather than separate from them).
invest in the application of existing creative problem solving and technical intelligence systems to food product and process design problems, and develop from there new systems or add-ons as needed. We recommend that a priority research area that complements any others should be the development of enabling tools for managing scientific information and knowledge. These technical intelligence systems for the food industry would help to systematise, store, search, retrieve and deploy in the appropriate moments, the scientific and technical knowledge required to solve specific problems. They would allow developers to outreach knowledge outside their particular fields of expertise, across areas of science and sectors of industry.	**emergence of information and knowledge as basic elements of new production systems.** As information and knowledge become "raw materials", they need to be processed and integrated multidimensionally in order to be used effectively. Every "raw material" shows this pattern when its diversity increases: the need for effective management will imply the development of systematic processing systems. In this particular case, "systems" include working methodologies as well as working tools.

FROM THE ANALYSIS OF SPECIFIC CONFLICTS OR HURDLES FOR DEVELOPMENT (WOIS ANALYSIS)	
We recommend the implementation of the following proposals...	***that relate to the following inherent contradiction***
Break legislation into various small modules, to the level of components of foods. It would be possible to envisage a system where a producer would only need to specify a product and its constituents to a computer interface, that would then access a database and compile the relevant pieces of legislation concerning the type of product, shelf-life, claims, ingredients, etc. specified. Once a company considers developing a new food product/process it only needs to access the system and is provided with a tailor-made collection of specifications.	Increasing consumer protection in spite of decreasing the amount of legislation
Let industry regulate itself: focus on results rather than methods. The system is segmented in two levels. At general governmental/EU level only major pieces of legislation that concern the crucial aspects of safety need to be regulated. Each company, brand name, or association of companies (in the case of SME's, industrial associations could undertake this task on behalf of each of its members) may set up its own specific standards that go further in detail regarding specific aspects, such as "organic product", "GMO-free", "suitable for diabetics/lactose intolerant/gluten intolerant/etc.", and so forth. What governmental/EU authorities need to do is check occasionally (audit) that the system implemented by a specific company regarding the standards of its products ensures the claims of the label. Different companies may have different systems and different ways of ensuring a given result. The implementation of this solution would imply a significant trust-building environment of the markets regarding the industrial producers and their brand names. The market will decide what products and standards it prefers with its buying behaviour.	

FROM THE ANALYSIS OF SPECIFIC CONFLICTS OR HURDLES FOR DEVELOPMENT (WOIS ANALYSIS)	
We recommend the implementation of the following proposals...	***that relate to the following inherent contradiction***
Same as 1 above. The amount of legislation that matters is the one that needs to be searched and complied with for a specific innovation task. By availing of an "intelligent" system that draws from individualised elements of legislation to produce a set which needs to be followed for a specific product or process from the inputs of what the innovations are, we minimise the amount of legislation that a particular company will need to contend with.	Increasing industrial innovation in spite of decreasing the amount of legislation
Same as 2 above. Let industry regulate itself. Regulating authorities will just need to enforce the most basic protection criteria and certify that the innovation process of specific companies (or groups of companies that self-regulate themselves through industry associations, for instance) takes into consideration the need for consumer protection to due extent. Consumer trust will need to build associated to specific brands or labels.	Increasing industrial innovation in spite of decreasing the amount of legislation *(continued)*
Instead of using methods that seek to ensure quality and constancy by following a fixed set of rules and procedures, we could devise the possibility of certifying any system set up by a company (or group of companies) on the basis of achieving results. Instead of micromanaging quality, we empower by focusing on results, not procedures - let industry regulate itself.	Increasing product quality in spite of decreasing the intensity of standard methodologies
Conceive a series of sub-systems of legislation at increasing levels of detail. The product label would need to specify which levels the product conforms to.	Increasing diversity in spite of increasing harmonisation of legislation

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Products can be divided in standard "modular components" that can be harmonised, and the final product is assembled as close as possible to the final consumer (maybe by the consumer him/herself) providing a unique final result. The production system is therefore composed of several production steps that produce components in some parallel network and a final intermediary assembly step where the various components are brought together, with maybe some capacity for slight modifications in specific components as well.	Increasing customisation in spite of increasing the uniformity of products
Deploy Genetic Technologies only where needed to solve a problem of direct benefit to the consumer; disseminate the product by focusing on the problem it solves, the benefits it gives; the technology is a tool, a means to achieve a goal. Abandon GM where there are little benefits that affect the consumer directly.	Increasing market acceptance in spite of increasing the use of genetic modification
Foster effective HACCP-type approaches to safety which include consumer home handling.	Increasing safety in spite of decreasing the intensity of testing
Development of sensors that can provide information directly to the consumer at the time of usage, such as TTI's, highly specific DNA probes that may detect the presence of even small quantities of specific pathogens, "home safety kits".	Increasing safety in spite of decreasing the intensity of testing *(continued)*
Use replacers, noting that "dosage makes the poison"; deploy "placebo effects"; develop products that give enjoyment and satisfaction of consumption while being nutritionally poor (fillers).	Increasing pleasure in spite of decreasing stimulating ingredients

FROM THE ANALYSIS OF SPECIFIC CONFLICTS OR HURDLES FOR DEVELOPMENT (WOIS ANALYSIS)	
We recommend the implementation of the following proposals...	***that relate to the following inherent contradiction***
Develop knowledge management systems for consumer use concerning nutritional and functional/bioactive ingredients. Pieces of information must be segmented and organised in classes and different levels of knowledge. A suitable relational database, neural network, or semantic knowledge processing technology will then be able to extract specifically only the information required. The idea is to minimise the amount of information that is scanned by a person when making a judgement, focusing only on the issues of relevance to the individual.	Increasing understanding and capacity for judgement in spite of increasing the amount of information
Both food products and the human metabolism need to be divided in the relevant constituents and the interaction between them studied at the molecular level. This requires the understanding of human metabolism at that level, which is far from known, but is therefore a very important area of research for the future. It is at the molecular metabolic level that we need to operate to extract high quality, relevant and accurate information that can be speedily used by consumers and the food industry.	Increasing the accuracy of information in spite of decreasing the R&D effort