4th Workshop Bioeconomy

“Ingredients, Functional processed foods and health”

ITAL, 29th-30th November, 2016

4th Workshop Term of Reference (ToR)

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Introduction

The main objective of the Public Policy Project in Bioeconomy (PPPBio) is to develop a Roadmap of the Bioeconomy for Brazil focusing on São Paulo State and more specifically on Campinas Region. The main idea is to create the basis for a world-class ecosystem in bioeconomy for Brazil that could be replicated in other regions and serve a model to boost Brazilian economic development.

Considering the necessary global effort and Brazilian Government commitments, the PPPBio Project proposes the following vision:

*The Brazilian economy, in the next 10-35 years, will experiment a transition towards the bioeconomy in substitution of petroleum-based (fossil) economy. This transition will take place with the promotion of high value sustainable bio-based products, derived from agriculture, food, health, bioenergy and green chemistry, will have to be effective, efficient, and advantageous from the environmental, social and economic points of view, in order to consolidate the expansion of the Brazilian economy and its participation worldwide.*

From this Vision, three objectives arise: (i) reduce GHG emission, (ii) increase number of formal jobs and (iii) create new products (Cortez, 2016):

One of the important research topics considered in this project, previously selected and considered relevant by the group of researchers from the members of the Agropolo Campinas-Brazil, are *Ingredients, functional processed foods and health*, more specifically ingredients and functional processed foods whose health effects have been scientifically proven, which is the focus of this Workshop, entitled “Ingredients, Functional processed foods and health”. The main objective of this Workshop is to structure project research themes and
to allow a good interaction with the private sector, which will create the necessary activities to develop the bioeconomy in the different sectors or areas.

This ToR presents a first draft of the Desired products, technologies or processes, the Critical System Requirements, Large Technological Areas, Technology Drivers, Present Scientific and Technological Capabilities, and Gaps and Barriers, which shall be discussed, amended or changed by Speakers and Panel Members, and also by the participants during debates and Analysis and Breakout Sessions.

It is expected that after the workshop the Technological Development Strategies and Conclusions can be reached.

**Section I – Desired products, technologies or processes**

This section aims to present needs that are specific to ingredients and functional processed foods whose health effects have been scientifically proven.

The development of new ingredients with functional properties as well as the expansion of use of existing ones will expand the functional products offer, going to meet the need for a market that in the past decade has grown above food and drinks as a whole. Functional products should continue growing in the coming years, taking into account the following drivers:

- Increase of the population;
- Increase in the number of elderly people;
- Increase of processed foods consumption;
- Increase in the cost of health care;
- Increase in the number of people with chronic non-communicable diseases - NCDs;
- Increase of consumer interest by the interrelation between food and health;
- Increase of schooling and income;
- Increase of diet segmentation;
- Faster Advance of CT&I, especially in the areas of biotechnology, nanotechnology, systems biology, synthetic biology, bioinformatics, nutrigenomics, automation and robotics.

The growth of ingredients, functional foods and beverages markets will have a positive impact in the three main objectives of the bioeconomy project:
Creation of new products with high aggregated value: The growth in the ingredients and processed foods markets and the increase of embedded technology in them will lead to greater added value to the whole sector. The high degree of embedded technology is evidenced by the wide availability of patented and sophisticated products. According to REAVELL (2012), the strategy of big ingredients companies is to increase the participation of special ingredients in their product portfolios (adding value), which calls for strong investment in RD&I.

- Increase number of formal jobs: Also in this case, the growth in the sector will increase the generation of formal jobs, especially jobs with higher qualification.

- GHG reduction: Coming to a set of factors, namely:
  a) adoption of cleaner technologies by industries;
  b) increase of industry productivity;
  c) increase the option for integral utilization of raw materials;
  d) greater efficiency in the application of bioactive compounds;
  e) reduction in the use of the health system.

The inputs to be considered are the following:

- **Ingredients**: all those which have their functionality scientifically proven, preferably protected (micro or nanoencapsulated) to avoid losses during processing, to obtain the best use after consumed (targeted delivery, bioavailability) and shelf life of at least a year. That is, to fulfill all these requirements and can be offered on the market, the raw ingredient has that worked through several steps, as for example: verify if the identity of the molecule is preserved; verify that the content was kept; to test their effectiveness; go through different processes, including those that will be responsible for its preservation and protection.

- **Processing**: especially those that preserve the functional components. For such preservation, adjustments in procedures are necessary, which have to be studied on a case by case basis. Among others, it is necessary to adjust the following parameters: formulation, flow, pressure, temperature and curing time.

- **Products**: the most varied possible, in order to enlarge the spectrum of options for the consumer.

It is very likely that the market for ingredients and functional foods will continue to grow in the coming years, since there are several factors pointing in that direction. The question is whether this growth will be similar to that observed in recent years.
In addition, there are limiting factors that can interfere in this growth, such as a very conservative regulatory system, lack of skilled labor and lack of alignment with the world trends.

Another limiting factor is the cost of large-scale production of functional ingredient (extraction and purification process, microencapsulation or nanoencapsulation).

There is also the cost to prove scientifically the efficacy and safety in the use of the ingredient, and require:

- More complex researches;
- Greater analytical skills and more sophisticated equipment;
- Greater use of well-designed clinical trials to prove the alleged claims, mainly double blind randomized controlled ones;
- Meet the requirements of labelling and consumer information.

Aiming to reduce these limiting factors, the food and ingredients industry has expanded partnerships with research and development centres and with the pharmaceutical industry.

Another factor that can limit or boost the ingredients and functional foods is the proper communication with the consumer. A lot of research has to be dedicated to this theme, both to understand what consumers really want and to explain to him properly and effectively the positive effects of functional foods. It is difficult but necessary, because without consumer confidence it will be very difficult to move forward.

There is not a consensus among academia, government and industry about the way that the segment of functional foods and ingredients should follow, because it is a complex and multidisciplinary theme. There is, however, agreement on some points, whose improvement will bring development to several other segments such as increasing investment in CT&I, training of skilled labor and encouraging entrepreneurship.

**Section II – Critical system requirements**

Once the “product” is defined – ingredients and functional processed foods whose health effects have been scientifically proven – the goal of this section is to identify what are the critical qualities that it must possess, named **critical system requirements** (CSR). Here, a small set (preferably one for each strategic goal) of functional and performance requirements is identified, characterizing the high level dimensions that the “product” of this specific
Technology roadmapping (TRM) component must seek, as well as its long term targets, preferably quantitative.

In short, CSR are high level parameters most critical to solve the problem of (i) creating new products that may contribute to the (ii) reduction of GHG emission and (iii) increase the number of formal jobs, in accordance to the Vision. Each CSR must be a reflection of the strategic goal (and corresponding targets) defined in the Vision, and also its long term target must be broken into intermediate ones: today, 2025 and 2050.

For this TRM component the CSRs are:

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Create new products with high aggregated value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Number of functional products launched per year*</td>
<td>80</td>
<td>129</td>
<td>557</td>
</tr>
<tr>
<td>Increase number of formal jobs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Growth of the functional foods market**</td>
<td>USD 10 billion</td>
<td>USD 16 billion</td>
<td>USD 69 billion</td>
</tr>
<tr>
<td>Contribute to GHG reduction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Growth of industry productivity***</td>
<td>100</td>
<td>113</td>
<td>237</td>
</tr>
</tbody>
</table>

* As the functional products have higher aggregated value, the greater the number launched each year, the greater the aggregated value.
** The higher the functional products market is, the greater the number of formal jobs created.
*** As the food industry productivity increases, the emissions will be lower.

For the calculations above, were considered the following growth rates:
- Number of functional products launched – 10% per year (2016-2020) and 5% per year (2020-2050).
- Growth of the functional foods market – 10% per year (2016-2020) and 5% per year (2020-2050).
- Growth of industry productivity – 2,5% per year (2016-2050).

Section III – Large technological areas

While the two previous sections identified (1) the products/technologies/processes focused and (2) its systemic requirements, the goal of this third section is to identify the technology areas that must be explored in such a way that products’ requirements will be met. Their evolution will determine how they will contribute to meet the product’s critical requirements.
Additionally, this section also presents the capabilities of the current Science & Technology system currently in place in each of the technology areas presented here, including a description of state-of-the-art technologies considered. It is supposed to be a competency map present in Brazil.

To achieve the projections pointed by the CRS, the contribution of the following areas will be of great importance:

1 - **Definition of new types of processing and or new processing parameters for the various products aiming to protect functional compounds present in products.** The addition of a functional ingredient directly to product is possible as long as you study what is the better food matrix for its addition in order to preserve its functionality and does not change the characteristics of the product. When this is not possible and there is a greater challenge in the association between functional ingredient and product, barrier technologies (microencapsulation and nanoencapsulation) can be useful to overcome the challenge.

2 - **Microencapsulation:** this technology has become highly important for food process because it protects the ingredient during storage or processing and releases it at the right time and place. Many ingredients can be microencapsulated as vitamins, prebiotics, probiotics, flavours, etc. Obtaining a stable functional ingredient is inadequate if it cannot be easily integrated in the food. Many ingredients are hydrophobic and dispersing them in hydrophilic food powders is a real challenge. In addition to protecting them, microencapsulation allows their conversion to suitable and manageable powders.

3 – **Nanoencapsulation:** this technology is similar to microencapsulation aside from it involving smaller (nano) particles. This size reduction can improve some interactions of functional ingredients and the body metabolism as its absorption and bioavailability. This technique is already commonplace within a range of industries but it is accepted that only around 10% of potential applications are being exploited.

4 - **Nutritional genomics:** comprises the nutrigenomics (effect of the diet components on gene expression) and the nutrigenetic (effect of genetic variability or polymorphism on diet components). It is important to highlight that in recent years the study of the epigenome, set of substance involving the genome and that control its operation, and of epigenetics, set as inheritable change in gene expression without any change in the primary sequence of DNA, has grown. DNA methylation, modification of histones and microRNAs are the most important mechanisms of this process. The epigenome can be altered by environmental factors, including diet, that is one of the main.

The development of nutritional genomics depends on deepening knowledge in the areas of systems biology and human microbiome, as detailed below:

Systems biology is the study of the interactions among the thousands of human genes and thousands of diet components. This is an area of high complexity, because of the
interaction occur in different phases (transcription, translation and metabolism) and in different mechanisms (bioavailability, DNA repair and transport) and in different organs and systems of the body, including the gut microbiome. Understanding these molecular mechanisms is to understand how food and its components modulate the health. Such studies are being made possible by omic technologies (transcriptomics, proteomics, and metabolomics), sophisticated analytical techniques that allow for the simultaneous analysis of thousands of molecules such as RNA, proteins and metabolites in human tissues and fluids, food and microbiome (LAJOLO, 2014).

The development of systems biology will also allow: find new molecular markers and genetic predictive markers of changes in physiological balance changes in physiological balance that, if maintained, may lead to diseases; Develop compounds, foods and interventions to avoid changing the balance and the consequent development of diseases; and Establish the foundations of individualized nutrition, the action of bioactive compounds and the demonstration of efficacy of functional foods claims (LAJOLO, 2014).

Recent studies have shown the influence of gut microbiome in energy metabolism, bioavailability of nutrients, endocrine and immune systems and even in the central nervous system, through the gut-brain axis. The intestinal microbiome varies with the individual and with the diet and, if his harmonic interplay with the body and balance are disrupted, diseases may appear. Therefore, knowing the ingredients and functional food interactions with gut microbiome is essential to define gut health predictive biomarkers and also for the definition of claims (LAJOLO, 2014).

Biomarkers used for healthy population have distinct characteristics of biomarkers used in patient population, that are based on clinical trials. It is therefore important to establish more appropriate criteria, based on the totality of the evidence as evidence, epidemiological, animal trials, mechanisms and biological plausibility of more evenly, i.e. evidences that reduce the emphasis in clinical trials as the only ones able to demonstrate cause-and-effect relationship. The harmonisation of criteria and claims is not simple and there has been a convergence of several countries to seek human intervention trials of high quality. As it is not always possible or ethical to evaluate the effect of a bioactive compound in the reduction of risk of a disease, it is necessary to develop predictive biomarkers or surrogate of the desired effects (LAJOLO, 2014).

5 - **Identification, extraction and purification of bioactive compounds:** To master these techniques is important, especially for exploratory studies. We highlight here the richness of the Brazilian biodiversity, which presents enormous potential.

6 - **Organic synthesis:** This competence is important because it can enable the commercial production of bioactive compounds isolated from nature by chemical synthesis.

7 - **Fermentation, extraction and purification of bioactive compounds:** This competence is important because many bioactive compounds are produced by
microorganisms. In addition, genes that encode bioactive compounds isolated from nature can be cloned in microorganisms, which are capable of synthesizing them by fermentation, allowing its commercial production.

8 - **Synthetic biology:** the use of these techniques simplifies the process of fermentation, considering that genes of interest are cloned in a standard microorganism, which chromosome is synthetized and whose nutritional demands are well known (VIALTA, 2014).

### Section IV – Technology drivers

In this stage, each CSR is mapped / transformed into technology drivers for each of the large technology areas previously identified. These technology drivers are critical variables in the identification of technological alternatives that will be selected later.

The research team presents goals for each of the identified technology drivers, which correspond to the CSR that the “product” must possess. The technology driver’s goals specify how well a technology alternative must do in a given timeframe. In other words, the goals are defined for the final system delivery that one foresees at the end of the timeframe (Vision – 2050).

<table>
<thead>
<tr>
<th>Technology Drivers for technological areas</th>
<th>Current</th>
<th>2020</th>
<th>Vision (2050)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition of new types of processing and or new processing parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Number of unconventional methods of processing established</td>
<td>low</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>• Level of processing automation</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td><strong>Microencapsulation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Development of new techniques of microparticles production</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td>• Development of new structure (wall) materials</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td><strong>Nanoencapsulation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Increase capacity to scale up the particles production</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td>• Increase analytical capacity</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td><strong>Nutritional genomics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Omic technologies development</td>
<td>medium</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td>• Knowledge of human microbiome</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td><strong>Synthetic biology</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Development of chassis microorganisms more efficient</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td>• Increasing of engineering approach in biology</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td><strong>Organic synthesis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Development of analytical technologies</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td>• Development of organic catalysts</td>
<td>low</td>
<td>medium</td>
<td>high</td>
</tr>
</tbody>
</table>
As shown above, it is very difficult to establish quantitative targets for indicators.

Section V – Present scientific and technological capabilities

This section presents the capabilities of the current Science & Technology system currently in place in each of the technology areas presented here, including a description of state-of-the-art technologies considered. It is supposed to be a competency map present in Brazil.

- Definition of new types of processing and new processing parameters

Brazil offers infrastructure and trained personnel with critical mass to work on that subject.

- Microencapsulation

The number of applications for microencapsulation technologies in foods, and especially functional food, is increasing. However, many challenges still remain. For example, incorporation of water-sensitive ingredients in high moisture foods is not solved because most capsules impermeable to water are not soft and will be detected by consumers.

Developing a microencapsulated product is a challenge, requiring a multi-disciplinary and integrated approach. Despite of existing many microencapsulation technologies currently, many are still at the development stage. Fortunately, the scientific and industrial community are organizing themselves in this regard. One example is The Bioencapsulation Research Group – BRG (http://bioencapsulation.net/), one of the largest non-profit associations on applied microencapsulation.

The global microencapsulation market was worth USD 5.6 billion in 2015 and it is estimated to be USD 8.4 billion by 2020. The market size is expected to expand at a CAGR of 8.6% over the period of 2015 to 2020 (BUSINESS WIRE, 2016).

In Brazil, despite the large number of studies, the number of purely national commercial products based on micro-encapsulation is still modest. In many cases, the applied microparticles used in national products are imported (ALVIM, 2014). Such a reality is observed in the study which showed that of the 80 patents deposited in Espacenet® in 2011, only one was from Brazil, highlighting the need for greater public and private sector investment in this technology (AHMED et al., 2014). This study also showed a trend of increase in the number of deposits over the years, mainly between 2001 and 2011, indicating that many innovations have been carried out.

- Nanoencapsulation

Despite important efforts (ABDI, 2010), nanotechnology is still in its infancy in Brazil, in need of public and private support not only for technological development, but also for the
commercialization of products and services resulting from the application of this technology. The Brazil has identified opportunities in the area of food, but has still faces the following challenges to win: establishment of regulatory framework defining clearly the possibilities of its application and the responsibilities on the risks assumed; definition of investment policies that enable the scientific advance and technological diffusion of nanotechnology; creation of governance mechanisms that facilitate communication with society and provide greater transparency about the benefits and risks of nanotechnology application (PISCOPO et al., 2013).

GIA announces the release of a Comprehensive Global Report on Nanoencapsulation for Food Products. The global market for nanoencapsulation for food products is projected to reach US$8 billion by 2020, driven by strong demand for functional foods, and improvements in nanoencapsulation techniques (GLOBAL INDUSTRY ANALYSTS INC., 2015).

The following table shows the types of influence that the demand drivers of ingredients, food and packaging sectors will cause in the areas of micro and nanoencapsulation.

<table>
<thead>
<tr>
<th>Driver</th>
<th>Microencapsulação</th>
<th>Nanoencapsulação</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing demand for functional products</td>
<td>Strong influence</td>
<td>Strong influence</td>
</tr>
<tr>
<td>Rising demand for better food packaging</td>
<td>Medium influence</td>
<td>Strong influence</td>
</tr>
<tr>
<td>Surging interest in ethinical, flavor and gourmet food</td>
<td>Strong influence</td>
<td>Strong influence</td>
</tr>
<tr>
<td>Need increase shelf life of processed food products</td>
<td>Medium influence</td>
<td>Strong influence</td>
</tr>
<tr>
<td>Demands in delivery systems of botanical products</td>
<td>Strong influence</td>
<td>Strong influence</td>
</tr>
<tr>
<td>Growing demands in encapsulation food additives</td>
<td>Strong influence</td>
<td>Strong influence</td>
</tr>
</tbody>
</table>


The Government created the National System of Laboratories in Nanotechnology - SisNANO (www.mcti.gov.br/sisnano), directed to the research, development and innovation in nanosciences and nanotechnology, having as essential characteristics the multiuser character and the open access, upon submission of R,D&I project proposals or service request. The Government joined in the NANoREG Project (http://www.mcti.gov.br/projeto-nanoreg), which deals with international regulation in nanotechnology. The initiative was proposed by the European Union and coordinated by the Ministry of Infrastructure and Environment of the Netherlands. In return, Anvisa created in August 2014 the Internal Committee of Nanotechnology - CIN to discuss and present an agenda aiming to regularize the theme. In this context, the real application of nanostructured food ingredients is still not allowed (ALVIM, 2015). These are important initiatives, but insufficient.
Brazil began supporting the development of nanotechnology research in 2001, at the same time as countries such as United States and China began their programs, however, comparatively, the country has advanced little. Brazil needs to concentrate efforts to boost this area as it is a big producer of food.

According to Alvim (2015), nanotechnology has important challenges for its implementation in Brazil and in the world, the main ones are: limitation of financial resources and specialized personnel; Inadequate production processes or not fully established yet; Definitions, characterisation and evaluation methodologies of nanomaterials are not completely established; Obtaining conclusive information regarding the risks and impacts on health and the environment; and consumer acceptance.

- **Human microbiome**

According to D’HONDT (2016) human gut microbiome is a key biological interface between human genetics and environmental conditions influenced by nutrition. While the food industry such as Nestlé and Danone has clearly stated interests in gut microbiome, the pharmaceutical industry and several innovative biotechnology companies have also identified this issue as a potential target to address chronic diseases. Although the scientific insights in the field are growing fast, large challenges remain in terms of developing an evidentiary base, standardisation and acceptance of harmonised regulatory frameworks.

The characterisation of the complete human microbiome was one of the next big challenges after the finalisation of the human genome project, launched by National Institutes of Health – NIH in 2008. The availability of novel high-throughput omics technologies now for the first time made it possible to characterise complete microbial communities without isolation and pure culturing of individual species (D’Hondt, 2016).

In 2008, it was also launched the International Human Microbiome Consortium to share data related to the human microbiome and make data freely available to the global scientific community to create a better understanding of the role of microbes in health and disease. The consortium aims to harmonise the work focused on the human microbiome and co-ordinate activities and policies of international groups and is open to other partners willing and able to participate according to the policies of the consortium. Members now include Australia, Canada, China, France, Japan, Gambia, Korea and Ireland. There are other more recent initiatives for a harmonized effort to address microbiomes or microbial ecosystems in general such as Unified Microbial Initiative – UMI and International Microbiota Initiative – IMI (D’Hondt, 2016).

There are in Brazil several research groups working with human microbiome and exploring its interface with the various issues, such as obesity, biomarkers, chronic inflammation and diabetes, among others, and using tools of systems biology. There is a concentration of these groups in the State of São Paulo (USP, UNESP, UNICAMP, FACISB), but there are several other important groups in other States.
- Nutritional genomics

Although it is a science created recently, it develops rapidly in the world due to its high innovation potential. In Brazil, there are several research groups working on this theme.

- Identification, extraction and purification of bioactive compounds; fermentation, extraction and purification of bioactive compounds:

   Brazil offers infrastructure and qualified personnel working in these areas, but it lacks a development plan focused on functional ingredients and contribution of specific resources for its implementation. Be competent in these areas means to qualify for the exploitation of our biodiversity and to achieve commercial production of isolated substances. Synthetic biology, described below, is a more recent area of research and has a much greater potential to achieve commercial production of compounds of interest.

- Synthetic biology

   Brazil has several research groups working in synthetic biology both in the public and in the private sectors. An example of this is the INCT Synthetic Biology - BioSyn, coordinated by the researcher Elíbio Leopoldo Rech Filho and which involved four units of Embrapa, four units of Fiocruz, Unicamp, the joint unit GenClima (Unicamp and Embrapa), UnB, UFPE, UFRJ. Brazilian companies participants are Amyris, Orygen, Tecsinapse and Invent. Abroad participate in the j. Craig Venter Institute, UC Berkeley and Missouri Botanical Gardens (United States) and the Genome Analysis Center (England).

   BioSyn's proposal is to form a network of interdisciplinary research in biotechnology applied to adding value to biodiversity. The BioSyn will support and will be included in the consortium of synthetic biology "OpenPlant" (Open Technologies for Plant Synthetic Biology), formed by the most important universities, companies and research institutes of Brazil and in the world working with the theme of synthetic biology.

   The focus of research will be the study of biological function by function analysis, gene expression and accumulation of metabolites present in the native species of the Brazilian biodiversity and biotechnology with economic interest. The second step will be to built a database of genomes of plants and microorganisms, integrating data coming from genomic, transcriptomic, genetic variants and metabolomic.

   All results will be created within a model of open innovation and competitive cooperation, where the partners come together in the development of technology, and then individually or collaboratively, the products or services are made available to the society.

   Among technologies and technology platforms are expected the mass treatment of large genomes, the generation of omic database for integration and data mining, biological circuits design, generation of synthetic genes and development of chassis for biological factories. At the end of the project, are expected to products such as: database of species
biodiversity and Brazilian industrial interest, tools and know-how for the design and production of biological circuits, factory of genes and biological chassis for synthesis of various products such as resveratrol produced in yeast.

- **Organic synthesis**

According to Correia and Oliveira (2011), the strengthening of the concept of green chemistry from the 1990s promoted a change in the paradigm of organic synthesis which led to the resurgence of organocatalysis (a valuable alternative to the development of new synthetic tools). The organic synthesis has developed a lot in the last 60 years thanks, in large part, to the emergence of more precise analytical methods (NMR and $^1$H e $^{13}$C mass spectrometry, new methods of chromatographic separation, etc), the rational strategic planning of routes and the power of new synthetic methodologies.

Correia and Oliveira (2011) claim that the organic synthesis has been adapted to the new demands of society and the scientific community, citing as an example the fact that they act jointly to target-oriented synthesis (synthesis of a specific molecule, usually a natural bioactive product) and the function-oriented synthesis approaches (synthesis of molecules, or a set of them, in order to achieve a specific activity), being this last method widely used in discovering new drugs, hence the current and future trend of increasing interaction between the organic synthesis, medicinal chemistry, pharmacology, biology and biochemistry.

**Section VI – Gaps and barriers**

This section identifies current and future gaps and barriers concerning the technology drivers, including the future industry’s workforce skills and knowledge base that will developed and deploy the new technologies. Such identification may point to the types of strategic decision making that will be needed in terms of education and scholarly programs taken by policy makers.

The main technological gaps and barriers are:

- Lack of public and private investment in R&D
- Lack of access of small and medium-sized companies to the sophisticated equipment for processing and analyzing
- Low internationalization of the P&D activities in the strategic areas
- Low networking of the P&D activities in the strategic areas
- Lack of biomarkers and molecular procedures for demonstration of efficacy and safety of bioactive compounds
The main non-technological gaps and barriers are:

- Lack of a national plan for the development of the segment
- Lack of enough skilled labor
- Low entrepreneurship
- Regulatory agencies not aligned with market trends
- High costs for the demonstration of efficacy and safety of functional ingredients
- Lack of effective communication with the consumers to explain the real benefits of functional foods, helping them to feel less confused

**Section VII - Analysis**

With the technology drivers and its targets specified earlier, the goal of this section is to identify a *draft* of possible technology alternatives for meeting such targets, identifying the maturation time (learning curve) for each technology alternative, or in other words, the technology alternative progress to comply with the drivers’ targets.

It also identifies *preliminary* decision points – if more than one technological alternative have been identified – in which future teams responsible for implementing this TRM’s recommendations will have to take go-no-go decisions.

Important innovations to the growth for functional foods and ingredients sector should come from the following technology areas:

- **Processing**: mature technologies that enable the necessary adjustments for the processing of functional ingredients. Here it is necessary to consider the adoption of unconventional methods of processing (high pressure, omic heating, electrical pulse, irradiation, microwave, membranes and others which may arise in the period).

- **Microencapsulation**: mature technology and with the possibility of incremental innovations (new materials, new process conditions) and with space for radical innovations as new particle formation processes. An example is the "wave" of developing a spray dryer with controlled conditions of pressure and temperature for drying at lower temperatures, which can be very useful in microencapsulation.

- **Nanoencapsulation**: maturing technology that shows great potential for incremental innovations and even disruptive, given that the period considered is long (35 years). In the food area, this technology is in its infancy.

However, the greatest contribution to the development of functional foods and ingredients should come from the following areas;
Nutritional Genomics: new branch of science, but intensely studied. It should provide great development in the sector, since it analyses the interactions at the molecular level, a fact which facilitates the scientific proof of functional compound effectiveness. Its development depends on the advancement of knowledge in the areas of systems biology and gut microbiome.

More intense studies of gut microbiome started a little over ten years, but it is already showing very interesting results. These results allow to view its potential for the development of the sector.

Systems biology is a branch of science that uses omic technologies (transcriptomics, proteomics, and metabolomics), sophisticated analytical techniques that allow for the simultaneous analysis of thousands of molecules such as RNA, proteins and metabolites in human tissues and fluids, food and microbiome.

- Synthetic biology: it is a new branch of science, but with great potential to enable the commercial production of functional ingredients isolated from nature.

- Organic synthesis: area that has developed a lot in recent years and that also has great potential to enable the commercial production of functional ingredients isolated from nature.

- Identification, extraction and purification of bioactive compounds and fermentation: mature technologies with the possibility of incremental innovations.

Conclusion

The most important, strategically, to Brazil is the construction and implementation of a national plan for the development of functional foods and ingredients that includes actions such as:

- Deep sector diagnosis that qualifies and quantifies the resources and infrastructure available and pointing the barriers and gaps, as well as opportunities.

- Prioritization of actions that make possible to eliminate the barriers and gaps.

- Prioritization of areas in which Brazil has comparative and competitive advantages.

- Creation of public policies needed to stimulate the development of the sector.

Some expected results for the implementation of a National Plan would be:

- Creation of a multidisciplinary centre to support and validate the scientific proof of functional properties, with an unique alignment and in line with international standards.
- Creation of a human intervention trial platform to address challenges such as subject recruitment and lack of standardization for clinical trials, establishing hard end points and clinical tools that are non-invasive and repeatable.

- A balance between randomized controlled trials (RCT) and population studies to determine best practices to manage nutrition issues.

- Identifying validated biomarkers of exposure and effective use of emerging ‘omics.’

- Integration of different types of approaches and study methods, such as basic science, clinical research, and population-based studies.

- Developing methods and tools to implement the knowledge of nutritional genomics, omic sciences and nanoscience.

- To increase the networking.

- Increase the degree of internationalization.

- Interdisciplinary research to determine if food and nutrition policies are achieving what is intended.

- Adequacy of Brazilian regulatory agencies in order to result in measures such as: approve a code of practice for the application of functional foods and beverages claims; approve a code of practice for the installation of new food and beverage categories in line with international trends, to accelerate the deployment of innovation in the country.

**Workshop Objectives**

The purpose of the WS4 is to draw a roadmap for Ingredients, functional processed foods and health.

**There are three strategic goals that must be achieved:** a) create new products with high aggregated value; b) Increase the number of formal jobs; c) contribute to reduce greenhouse gases (GHG) emissions.

It is expected that WS 4 pinpoints the opportunities for Ingredients, functional processed foods and health, to stimulate research and to encourage the creation of technology based businesses or start-up companies.

WS4 will be organized in five panels, each one covering one key topic of the main theme. The panels will have a speaker, with deep knowledge of the issue, which will bring the state of art of the topic, answer specific questions, and point out critical information for the designing of the roadmap, and two panelists which will analyze and complement the speaker
presentation and help to bring issues that are important for the roadmap. Finally, the section will be opened for questions, comments and discussion by the general audience.

At the end of day 2 the participants will form three groups of experts for breakout sessions in order to discuss how to achieve the three goals above mentioned taking into consideration the information brought about in the panels.

**Guidelines for speakers and panel members:**
In order to facilitate the roadmap process, key points should be addressed by all speakers and panel members, bringing quantitative data and targets, in addition to listing technological areas and capabilities, gaps, barriers, and opportunities. The solution of some of the gaps may stimulate joint actions with the academic and the private sectors to help creating of enhancing a new bioeconomy system in Campinas.

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<tr>
<th>Needs and technological capabilities</th>
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<td>Desired solutions/products</td>
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<td>Technological areas involved</td>
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<td>Technology drivers</td>
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<td>Current scientific and technological capabilities</td>
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<td>What may prevent or stimulate changes?</td>
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<tr>
<td>Gaps and barriers (scientific, legal/legislation, economic, labor, lack of qualification, lack of investment, etc.)</td>
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<th>Technological development strategy</th>
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<tr>
<td>Technological alternatives, recommended technologies</td>
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<td>Budget and investment needed</td>
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**Each Section: 90 min**
- Opening: 10 min
- Speaker: 35 min
- Panel Member: 15 min
- Panel Member 2: 15 min
- Discussion (Q&A): 15 min
DAY 1 – November 29th, 2016

Session 1: Brazilian scenario: ingredients, functional foods and health
Main questions:
1. What is the market, forecast and statistics of functional ingredients?
2. What is the market, forecast and statistics of functional foods?
3. What are the most relevant chronic non-communicable diseases - NCD currently and its impact on the functional food market?
4. How can knowledge of human microbiome impact the functional food market?
5. How can the nutrigenomics impact the functional food market?

Session 2: The Brazilian consumer and the issue of communication
Main questions:
1. How to communicate technical facts to the lay population, mainly using the social media?
2. How can we make the connection between what consumers say they do or want to do and what is their actual behavior with regards to eating healthier?
3. How so Brazilian consumers compare with the rest of the world in terms of their knowledge and interest in health and nutrition?
4. What is the role of the environment when it comes to healthy eating?

DAY 2 – November 30th, 2016

Session 3: Technological adequacy of ingredients (embedded in this subject: integral exploitation of raw materials, production chains and chemical analysis)
Main questions:
1. How to direct/operate the research of ingredients so that it meets the real needs of the consumer?
2. How to solve or minimize the analytical limitations, especially with regard to proof of efficacy and safety?
3. How to solve or minimize the limited access to important raw materials for the area of ingredients?
4. How to solve or minimize the lack of specialized labor?
5. How to improve the relationship businesses – research and development institutions?

Session 4: Technological adequacy of products (embedded in this subject: integral exploitation of raw materials, production chains and chemical analysis)

Main questions:
1. How does industry attends an increasingly segmented market?
2. How to solve the paradox Naturalness x Industrialized?
3. How to meet the needs of consumers in relation to quality of life?
4. How can new technologies solve regulatory issues?

Session 5: Regulatory Issues (embedded in this theme: analysis necessary for proof of safety and effectiveness)

Main questions:
1. Why is Brasil seen globally as restrictive in relation to innovation platforms?
2. How to improve the treatment of imported and manufactured in Brazil with regard to safety and efficacy requirements?
3. How do regulatory agencies plan to face the challenge posed by new technologies?

References


