doi:10.2533/chimia.2019.767 Chimia 73 (2019) 767–769

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Hot from the press!

BioTech 2019 – ZHAW Waedenswil, July 4, 2019: Part 2
The Future of Food: Cellular Agriculture

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A secure supply of food around the globe is not to be taken for granted. On the one hand the world population is growing fast, about 230'000 people per day, on the other hand climate change as well as rapidly spreading diseases block the production of food dramatically. Crop losses in the largest growing areas amount globally to 30%. Cellular agriculture focusing on the sustainable production of agriculture products from cell cultures in a laboratory instead of using livestock may provide a solution.

"At ZHAW Waedenswil, experts and interested people from over the world seized the opportunity to learn about cellular agriculture and exchanged ideas with specialists from biotechnology, foodstuff technology, cosmetics and environmental technology", says Professor Dr ***Regine Eibl***, head of Cell Cultivation Techniques at ZHAW. "What is the potential of cellular agriculture for food production today? What about plant cell culture extracts used as food supplements and food itself? When will cultured meat from the bioreactor be commercially available? What can foodstuff technologists learn from biotechnologist? What is the current situation of microalgae and insect-based food? Let us talk on 4th July 2019 also about life cycle assessment!"

Meeting the Needs of Cellular Agriculture

David Welch is Director of Science and Technology of The Good Food Institute (GFI) in the US, a non-profit organization that promotes innovative alternatives to industrial animal meat, eggs and dairy products. The company brings together the scientists, entrepreneurs, investors, policymakers and companies working in plant-based meat, clean meat and supporting technologies. The challenge is steep: Global demand for meat is expected to rise by nearly 70% in the next 30 years. Yet livestock cultivation already occupies such a large fraction of habitable land that current meat production methods will be unable to meet this demand. The UK native is convinced that the most efficient meat production methods – those that involve intensive, industrialized systems – are plagued by a host of hazards such as severe environmental pollution and public health risks. This does not change the attitude of wealthy people: Despite increasing consumer awareness of these limitations and hazards, meat demand and consumption per capita continue to increase. And simply advocating for less meat consumption has not proven tractable…at least until the appearance of compelling alternatives.

David Welch, who combines his background in plant biology and regenerative medicine to help companies and academic research institutions to be active in this new domain, believes that the utilization of animal stem cells to grow muscle and fat tissues *in vitro* for consumption - dubbed 'cell-based meat' – offers an unprecedented opportunity to transform animal agriculture and produce meat in a humane and sustainable way. He knows what he is talking about, as he decided to adopt a plant-based diet a few years ago … with success! But while the nascent industry has seen lately important technological improvements, significant challenges remain if cell-based meat is to be price-competitive with conventional meat and available to consumers around the world. Along with innovation in the start-ups developing cell-based meat, we need more universities performing research to advance the field. Interdisciplinary research merging cell-biology, tissue engineering, biochemical engineering and food science is required to create cell-based meat, eggs and dairy products at scale to meet the growing demands of our global population with food that is sage, ethical and healthy.
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The Plant Cells as a Food Concept

Heiko Rischer is Head of Plant Biotechnology at the VTT Technical Research Centre of Finland Ltd. In his opinion the production of agricultural products from cell cultures under completely controlled and contained conditions bears the potential to tackle several of the grand challenges in sustainable food production by decoupling food and environment. Currently, *in vitro* meat receives most media attention although from a health perspective dietary intake of plant-based food is generally considered healthier. The 'plant cells as food' concept has emerged constituting an alternative to provide nutritional and healthy products.

The technical processes for the cultivation of plant cells are very advanced, even at large scale, since such systems have been commercially used to the production of phytochemicals, *e.g.* pharmaceuticals, cosmetics, pigments and additives. Scalability is a huge advantage allowing production scenarios ranging from decentralised 'home-bioreactors' and local 'greweries' to huge centralised factories.

Only recently, investigation confirmed the value of plant cell culture (PCC) biomass as food. PCCs contain nutritionally relevant combinations of proteins, carbohydrates and lipids, enriched with vitamins and health-promoting compounds. Additionally, they exhibit technical processability that influences digestibility and sensory attributes. Notably, the chemical composition of PCCs is not identical with the original plant although in principle the metabolic capacity is conserved.
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A Look at Chocolate from Cocoa Cell Cultures

It was 'only' a feasibility study, but ***David Schildberger***, researcher at ETH Zurich, and ***Philipp Meier***, research at ZHAW, knew that cell culture techniques enable us to deal with nature as a unique source rather than a consumable resource. It detaches food from its current context, allows for an *ad infinitum* cultivation and further potentially unlocks new expressions of inherent natural aroma spectra. The entailed artificiality does not merely aim to substitute for an existing nature but engenders an orthogonal space within the dimension of the symbolic – a space within which one can move freely by means of consistent arguments and sensible articulations. In order to show the potential in the context of Switzerland, they began to think about the cultivation of cacao for the production of chocolate and the affirmation of luxuriation, in its full decadence and decoupledness from an original nature.

Their approach was to make cacao powder and to produce a 'cell culture chocolate' by growing suspension cells from *Theobroma cacao* in a Flexsafe RM 20L bag with a screw cap from a BIOSTAT RM 20/50. The cell line – dark culture – was

established from a well-growing and friable callus clone, and has a doubling time of 4 days. It provided up to 40% higher concentrations of the polyphenols epicatechine, procyanidine B1, B2 and C1, and cinnamtannine A2 than cocoa beans from pods grown in Puerto Rico. The alkaloids caffeine and theobromine were absent in the cell culture grown in MS-medium. On day 16, about 300 g biomass – fresh weight – was harvested from the wave-mixed single-use bioreactor operated in feeding mode. Addition of an antifoam agent and pH-regulator was not required. The biomass was freeze-dried, resulting in ***in vitro*** cacao powder that was roasted and milled before adding sugar, lecithin and cocoa butter. Three blocks of dark chocolate – 70% – were produced, which provided the experts on the ZHAW's sensory panel with a unique taste experience. The flavour was intensive and complex, citric and berry flavours being predominant. The results demonstrate the suitability of wave-mixed and stirred bioreactors for the development of plant cell-based health-promoting food and food ingredients. Subsequent studies will focus on the influence of power input and shear stress on polyphenol formation, and the development of scalable low-cost bioreactor.

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Food Produced Using Animal Cell Culture Technology

Christian van den Bos, former Lonza employee, is director of the German company Mares Ltd. in Greven. In his opinion, a radical solution to the problem of food scarcity as well as food quality might be the production of food using tools of modern biotechnology. This opportunity meshes well with ethical concerns regarding the consumption of animal products for which animals have to be sacrificed, *i.e.* meats. First claims have been made towards this end, for example by offering rather extravagantly priced hamburgers. Considering taste and texture preferences, it might be tempting to consider generating entire animal tissues and to process these in a fashion similar to what is currently done. However, as the field of tissue engineering has learned rather painfully, it is still a challenge to produce even the simplest of tissues, let alone entire organs or, indeed body parts.

Consequently, simpler and more realistic approaches have to be devised to generate nutritious and ethical food pleasing to the palate. This is where the fields of stem cell biology, bioprocessing and food processing converge to offer the chance to product such foods at quantity and, hopefully, also economically. Food processing techniques provide currently products such as sausages by blending specific animal tissues into a pleasing mix. Instead of being harvested from animals, such tissues and their components may be generated using stem cell technology and then blended using food processing technology. Finally, bioproduction and processing provide the tools to produce the required components at scale and variants of established microcarrier technology may provide aspects important to *e.g.* texture experience. Indeed, one might consider mixtures of animal- and plant-derived materials of excellent nutritional and sensory properties.

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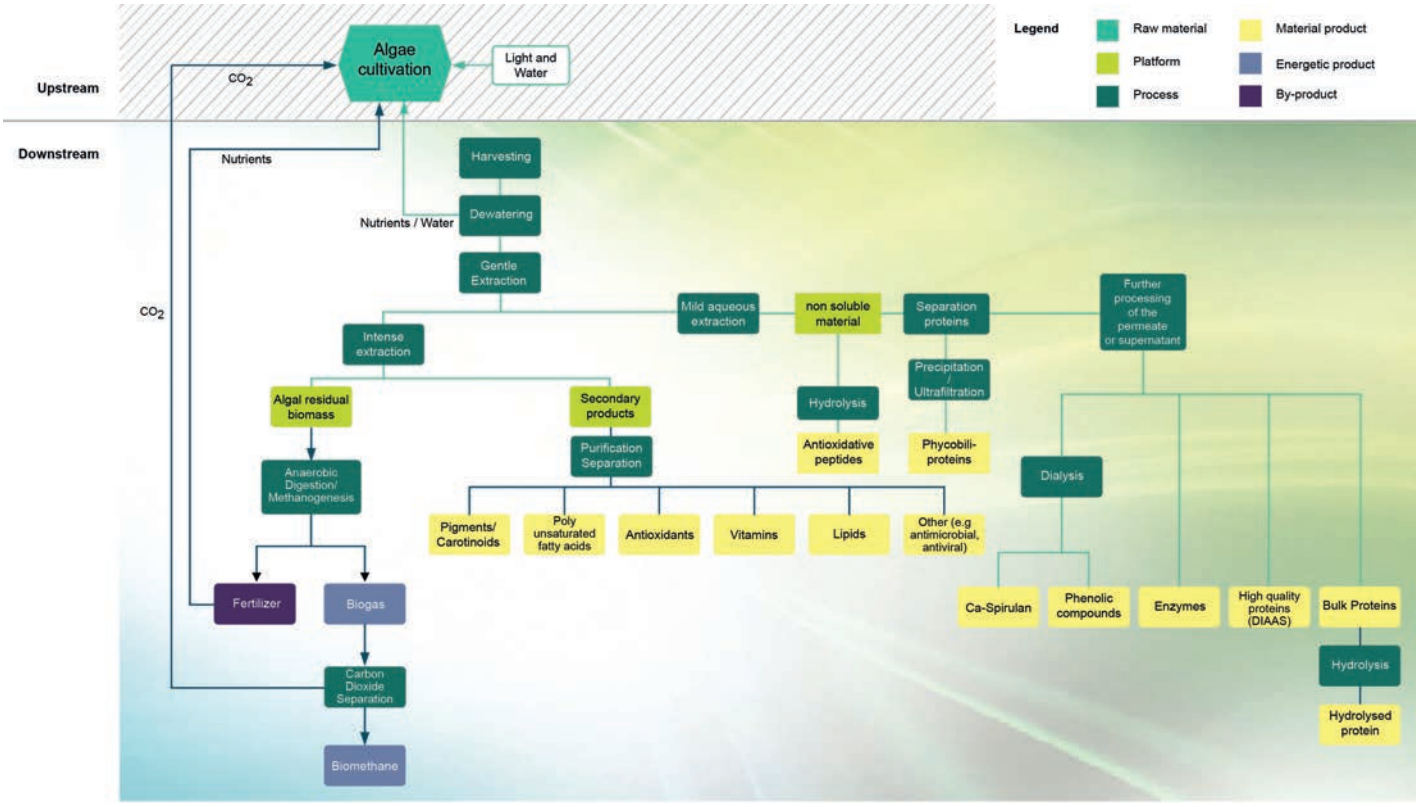
A System-oriented Approach in Food Production

He is Professor in the Department of Health Sciences and Technology at the ETH Zurich, where Sustainable Food Processing is daily routine. ***Alexander Mathys*** is convinced that sustainable food processing is the key driver of the bioeconomy covering process–product–operation interactions, where selected examples of innovative thermal, electromagnetic, mechanical and combined processed will be introduced. Advanced approaches relying on innovative raw materials from microalgae or insects and their connected biorefinery concepts could even increase the impact of sustainable food processing. Such innovative value chains could be linked to novel opportunities to value alternative protein sources. By using novel proteins from algae and insects, food security and sustainability of the protein supplies can be significantly improved.

Focused process development on modular micro process engineering as a process intensification tool enables more flexible



Alexander Mathys: Example to demonstrate bio-economy R&D based on food and bioprocessing *via* a more sustainable algae biorefinery concept with focus on high value ingredients and valorisation of all side streams for a 'zero waste concept'.

R&D and an ultrashort thermal treatment of foods within milliseconds (ms) using very high surface-area-to-volume ratios for targeted higher food qualities. Electromagnetic based nano second pulsed electrical field (nsPEF) and low energy electron beam (EB) allow an efficient use of biomass in food production. The application of these emerging continuous process technologies could enable the gentle microbial control of liquid systems with nsPEF and low water activity foods with low energy EB, while keeping their organoleptic properties.

During mechanical high-pressure processing, specific bacterial spore control concepts could be suggested through combined thermal and mechanical processes such as high pressure thermal sterilisation as well as continuous ultra-high pressure processing up to 450 MPa as innovative multi hurdle technologies.

Holistic life cycle sustainability assessment, aligned with the introduced process innovations, can evaluate the suggested solutions on a multi parameter base, in terms of improved food production sustainability.

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Received: August 8, 2019