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Editorial: Production, downstreaming, and utilization of proteins and exopolysaccharides from single cells in food matrices

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Editorial on the Research Topic
Production, downstreaming, and utilization of proteins and exopolysaccharides from single cells in food matrices

The production and utilization of single cells as a protein source in foods bears several advantages over conventional agriculture that relies on plant growth, such as adding an additional layer to food production with low needs for arable land (Grossmann et al., 2019; Sillman et al., 2019), increase the diversity of available foods (Grossmann et al., 2020), lower greenhouse gas emissions (depending on production technology used) (Smetana et al., 2017; Sillman et al., 2020), and serve as a resilient method for food production during extreme events (García Martínez et al., 2021). For these reasons, there is a high interest in production, downstreaming, and application of different single-cell types to produce foods based on such proteins but also exopolysaccharides. However, for sufficient and sustainable production of these components and their use in food matrices, both scientific and technological challenges still need to be overcome, which are reflected in the ongoing research of our contributors, summarized in this editorial.

Upstream processing

Exopolysaccharides play a vital role in many microorganisms and can be effectively utilized to modify the textural attributes—such as viscosity—of fermented foods without adding thickeners (Loeffler et al., 2020). Moreover, they may serve as antiviral, antibacterial, and antioxidative compounds. The contribution of Jung et al. showed that light, temperature, type of organism, and the type of cultivation influence the amount of exopolysaccharides produced in *Arthrospira platensis* and *Chlamydomonas asymmetrica*. Especially light had a strong influence on the exopolysaccharide production rate with an increase from $c_{EPS} = 0.13\,g\,L^{-1}$ at 96 $\mu mol\,m^{-2}\,s^{-1}$ to $c_{EPS} = 1.4\,g\,L^{-1}$ at the highest light intensity for *Chlamydomonas asymmetrica*. Conversely, light had only a modest influence on the production rate for *Arthrospira platensis* value with 0.024 g L^{-1} d^{-1} observed at 180 μmol m^{-2} s^{-1}, and the lowest value of 0.012 g L^{-1} d^{-1} at 975 μmol m^{-2} s^{-1}. Overall, the authors conclude that the highest yields can be achieved for *C. asymmetrica* at 30°C and 1,429 μmol m^{-2} s^{-1} with batch processing exceeding the production rates compared to continuous processing. This study thus has important implications for designing cultivation techniques that aim at achieving high exopolysaccharide yields in microalgae.

Downstream processing

Downstream processing of single-cell organisms is one of the most discussed and researched areas. Recently the processing of microalgae and microbial cells has been the main target for the production of proteins (Kumar et al., 2022), oils, or other special components usable e.g., in chromatography (Shukla et al., 2007; Käferböck et al., 2020; de Carvalho et al., 2022; Pleissner and Smetana, 2022). The studies indicated the increase of purity and amount of separated fractions and possibilities for the targeted separation in the case of application of emerging processing technologies. Knappert et al. for the first time revealed the relationship between permeabilization caused by Pulsed Electric Fields (PEF) and phycocyanin extraction, by discovering the relationships between the rate of cell wall permeabilization and the kinetics of particle decay. The authors were able to better clarify the release of cell metabolites (phycocyanin) in response to PEF treatment of *Arthrospira platensis*. Furthermore, the review of Pleissner and Smetana highlighted the studies, dealing with aspects of the utilization of microalgal cell walls left after PEF permeabilization for the purposes of chromatography. It was pointed out that the application of PEF allows to obtain cell walls with pores of various shapes and sizes, thus providing a suitable stationary phase for the separation by size exclusion, ion-exchange, and hydrophobic interaction chromatography.

Food applications

One challenge in the utilization of single cells is to find suitable food applications that are based on whole cells or their extracted ingredients. Beisler and Sandmann showed an exciting new application for *Arthrospira platensis* cells as a beer ingredient in a mild pale ale and India pale ale. The authors added *A. platensis* powder at different stages during the beer brewing process to replace 5% (w/w) of the malt and were able to demonstrate that the alcohol content after fermentation remained almost constant but other physicochemical properties such as pH and the free amino nitrogen changed upon addition of *A. platensis*. The sensory studies revealed that a stronger hoppy flavor as in the India pale ale recipe is necessary to still achieve a high consumer acceptance. The mild pale ale beers were generally perceived as less pleasant with a strong algal taste whereas a stronger fruity hop selection in combination with *A. platensis* powder added during the wort cooling resulted in overall high sensory scores of the blue-colored beer. When *A. platensis* is added before or during the heat treatment, the beers appeared golden to brown because of the low heat stability of phycocyanin—the blue pigment found in *A. platensis*.

To overcome these blue pigment instabilities Buecker et al. investigated the effect of different molecular weights of λ-carrageenan to stabilize extracted phycocyanin from *A. platensis* at pH 3 and 6 during heat treatment at 70 °C and 90 °C. The authors demonstrated that especially the untreated λ-carrageenan with a MW of around 2,314 kDa exhibited the strongest stabilization effects with the least color changes during storage. The blue color was especially retained at pH 3 where an interaction between λ-carrageenan and phycocyanin could be established. Decreasing the molecular weight of λ-carrageenan by ultrasonication decreased the color stability, but also the size of the formed complexes which may help to produce more translucent food formulations (if not overprocessed). These results have important implications for producing foods with blue colors where a long color stability is required.

Outlook

The widespread use of proteins and exopolysaccharides from single cells depends on sufficient yields and application potentials as well as on consumer acceptance. The editorial highlights some new and very interesting approaches in the mentioned areas but also shows the need for technologies to further increase the production rate of these components. Here, advances in genetic engineering, genome sequencing, and multi-omics analysis are currently paving the way for targeted increases in cell productivity. Together with the optimization of fractionation and extraction processes and a better understanding of the utilization of single-cell proteins and exopolysaccharides in complex food matrices, this will lead to single cells becoming even more important for the food industry and the global food supply.

Author contributions

All authors contributed equally to writing and editing the manuscript.

Conflict of interest

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