Development of an industrial process to extract nucleotides from fungal fermentation waste

Jonathan Paul Longden

Engineering, The University of Lancaster

A single UK facility supplies a large European market with a novel product, which is produced from large-scale fungal fermentation. This continuous fermentation process currently produces around 40,000 cubic meters of liquid waste per day, although this output is set to rise following proposed expansion of fermenter facilities, in response to increasing product demand. This liquid waste is currently disposed of via a complex multi-step effluent treatment process, before being discharged into local rivers. However, this waste has been shown to be rich in a number of valuable nutrients, chief among which are nucleotides.

Nucleotides are small biomolecules that fulfil a plethora of intracellular functions, including acting as the subunits of DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). Certain nucleotide forms are now widely used in the flavour, infant formula, pharmaceutical, animal feed and dietary supplement markets, as well as some use in academia. Most of the nucleotides that supply these markets are produced in China, which are then distributed internationally to suppliers in each market. Extraction of pure nucleotides from fermentation waste produced in the UK could provide a European production hub to potentially a supply a growing European and global market.

The proposed method will be based on a common procedure used in molecular biology for the isolation of intact nucleic acids. The method is involves precipitating the nucleic acids using a specific concentration of an inorganic salt, in combination with an organic solvent. This method exploits the differences in solubility between nucleotides and other biomolecules, so is able to selectively precipitate nucleic acids from a complex mixture of other biomolecules. Despite this procedure being almost routine, specific accounts of this method in literature vary significantly, including differences in type of salt, salt concentration, type of solvent, volume of solvent and addition of other components to increase yield. Initially, each variant of these precipitation protocols will be applied to the fermentation waste to determine which is most effective in extracting nucleotides. The method may need some adaptation for several reasons, not least to ensure the yielded nucleotides are safe for human consumption, and produced in a cost-effective manner. The method must also be focussed toward high yield, be tailored to suit the unique composition of the starting material and suitable for isolating pure nucleotides, rather than intact nucleic acid strands. Similar methodologies are already used industrially for large-scale nucleotide production, but evaluation of these methods is necessary to determine their effectiveness for this specific application.

The extracted nucleotides can subsequently be quantified using spectrophotometric techniques, and if necessary, can be processed further using chromatographic methods to give a highly pure product to serve certain markets. The ambition of this project is to produce a saleable product from an unused resource, which currently undergoes extensive and costly treatment before being disposed of into local rivers. In turn, this could potentially create a new multi-million pound market in the UK and Europe, which may spread further afield to supply markets in the USA, and so reducing the reliance on global shipping of nucleotides from China to companies in the West. Additionally, a high-quality nucleotide product may also generate an import market into China.