Process development for the production of a novel protein source

Background

The world population will grow towards 2050 and onwards [1]. One of the great challenges coming with this growth in population is the production of nutritious food in sufficient quantities. The nutritional value of food depends for a great deal on the protein content, hence a local, sustainable protein source, applicable in the food chain, will contribute positively to the world wide food security.

The protein

The protein from leaves, mainly the enzyme RuBisCo (ribulose-1,5-bisphosphate carboxylase/oxygenase), is a very promising, locally produced protein source. Most leaves are nowadays discarded on the field when crops are harvested, emitting CO_2 and NO_x in the rotting process that follows. In order to demonstrate the potential of this sustainable protein source TNO has worked towards a protein production process. This demonstration process is based on sugar beet leaves and realizes the production of a leaf protein concentrate that has a good nutritional value (AAS: 87%) [2], is highly soluble, has good functional properties [3] and possesses no known allergenicity [4]. These properties together make this protein very interesting for food applications.

The process

This proof of principle is based on sugar beet leaves, which contain on average 1% RuBisCo on wet weight bases [5]. The leaves are harvested with a machine that can match the capacity of 1 hectare per hour of a beet combine harvester. The leaves are collected without stems or dirt and transported to a processing facility. At this location the leaves are pressed with a conical screw press in order to release the water-soluble protein in the green juice fraction of the press. The green fragments in the juice are subsequently coagulated by heat treatment (50°C, 20 minutes) using plate-type heat exchangers and removed by centrifugation in a disc stack centrifuge. The remaining protein solution is concentrated and diafiltrated over a 100 kDa regenerated cellulose ultrafiltration membrane to remove salts, water and phenolic components from the cell walls. The last purification step is performed by hydrophobic adsorption using an XAD-resin to remove residual chlorophyll and phenolic components and ensure the production of a white and highly purified dry protein product after spray drying. This whole process has been executed at a scale of 1 metric ton wet leaves per hour input stream.

The product

The produced protein has been extensively tested on its functional properties, as this greatly determines the value of the protein for food manufacturers. The gelling capacity was found to be the most promising property of the protein, being more than four times better than whey protein and ovalbumin. This will allow applications in for example meat replacers, in which both gelling and nutritional value are of key importance as well as having a sustainable, plant-based origin.

Outlook

The coming years, the protein isolate will be tested by food producers in various products. Approximately 100 kg of protein isolate will be produced from sugar beet leaves by TNO in 2014 in order to facilitate these tests. Production on this scale will allow us to generate accurate numbers regarding sizing of equipment and detailed cost estimates for a full scale production facility.

References

1. UN. 2012. http://esa.un.org/wpp/Documentation/pdf/WPP2012_HIGHLIGHTS.pdf.
2. Barbeau, W. E. 1990. Functional properties of leaf proteins: criteria required in food applications. Italian journal of food science 4:213-225.
3. Barbeau, W. E. and J. E. Kinsella. 1988. Ribulose bisphosphate carboxylase/oxygenase (rubisco) from green leaves - potential as food protein. Food Rev. Int. 4:93-127.
4. Leduc, V., de Laval, A.D., Ledent, C., Mairesse, M. Respiratory allergy to leaf proteins involvement of a new allergen. Revue française d'allergologie et d'immunologie Clinique 2008, 48, 521-525
5. FAO. 2011. www.fao.org/DOCREP/005/AC854T/AC854T00.htm#TOCOnline.